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A MONOGRAPH
OF THE
FOSSIL INSECTS
OF THE
BRITISH COAL MEASURES.

BY
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PREFACE.

This monograph owes its existence to the friendly encouragement of Dr. A. Smith Woodward, F.R.S., Keeper, and of Dr. F. A. Bather, F.R.S., Deputy-Keeper of the Geological Department of the British Museum (Natural History), and to these gentlemen I am indebted for the loan of the undescribed Coal Measure fossil insects in their charge, and for much helpful assistance in other ways.

Others to whom my thanks are due are the Director of the National Museum, Washington, U.S.A.; Dr. F. L. Kitchin, of the Museum of the Geological Survey; Mr. G. W. Lee, of the Scottish Geological Survey; Dr. J. A. Clubb, of the Derby and Mayer Museums, Liverpool; Dr. W. E. Hoyle, of the National Museum of Wales, Cardiff; Prof. W. S. Boulton, of the Birmingham University; Dr. W. M. Tattersall, of the Manchester Museum, Victoria University; Mr. L. Gill, M.Sc., of the Hancock Museum, Newcastle; Mr. H. Y. Simpson, of the Kilmarnock Museum; and Messrs. Eltringham, S. Priest, W. Egginton, and D. Davies.

To Mr. W. J. Tutcher I am deeply indebted for his ready assistance in photographing all the various specimens submitted for examination. His remarkable skill has been always at my service, and by means of it I have been able to determine many details of structure which otherwise would have remained obscure.

I am indebted to the Royal Society for several grants towards the cost of the work.

H. BOLTON.

THE FOSSIL INSECTS OF THE BRITISH COAL MEASURES.

INTRODUCTION.

THE first recorded Palæozoic insect of any country appears to have been a British specimen, *Lithosialis brongniarti* (Mantell), which was discovered in the Coal Measures of Coalbrookdale in the early part of last century. It was sent by Mantell to Brongniart as a leaf impression. Brongniart in turn submitted the fossil to Mons. Audouin, who (1833, Audouin, 'Ann. Soc. Ent. France,' ii, Bull., p. 7) described it as "d'un insecte inconnu," and allied to the Hemerobiidæ, *Sembris*, and especially to *Corydalis* and *Mantis*. The specimen was afterwards figured and named by Mantell (1854, 'Medals of Creation,' vol. ii, p. 575, fig. 2).

According to Parkinson, however, Lhuyd first recognised fossil insects in the British Coal Measures. Parkinson ('Organic Remains,' vol. iii, p. 258, 1804—1811) states that Lhuyd in a postscript to a letter to Dr. Richardson wrote as follows: "Scripsi olim suspicari me Araneorum quorundam icones, una cum lithophytis, in schisto carbonario observasse; hoc jam ulteriore experientia edoctus aperte assero. Alias icones habeo, quæ ad Scarabæorum genus quam proximè accedunt. In posterum ergo non tantum Lithophyta, sed et quædam insecta in hoc lapide investigare conabimur." ('Lithophylacii,' p. 113.)

[“I have formerly written that I believed I had observed certain impressions of spiders identical with Lithophytes in carbonaceous shales; this I now, taught by later experience, openly assert. I have other impressions which approach nearest to the family of beetles. For the future, therefore, we will endeavour to investigate not only Lithophyta, but also certain insects in these shales.”]

Parkinson reprints four figures given by Lhuyd in his 'Iconograph,' tab. 4. Two of these figures show eight legs and must therefore represent the remains of Arachnids. None of the figures show wing-structure.

Interest in the occurrence of fossil insects was stimulated in 1837 by the publication of Dean Buckland's 'Bridgewater Treatise' on Geology, in which he described and figured two fossils found at Coalbrookdale by Mr. Anstice (1837, Buckland, 'Geology and Mineralogy,' 2nd ed., vol. ii, p. 76). He determined both specimens to be the remains of coleopterous insects—a determination since corrected by H. Woodward (1871, 'Geol. Mag.,' vol. viii, p. 386, pl. xi), by Scudder, and finally by Pocock, who referred them to the Arachnida ("Terrestrial Carboniferous Arachnida," 'Mon. Pal. Soc.,' 1911, pp. 39, 77).

Attention was afterwards diverted from the Coal Measures by the remarkable discoveries of insect-remains made by Brodie in the Purbeck and Liassic rocks, and by similar discoveries on the continent.

Mr. E. W. Binney (1867, 'Proc. Lit. and Phil. Soc. Manchester,' vol. vi, p. 59) exhibited a specimen which "bore some resemblance to the pupa state of a coleopterous insect," and had been found in the Cinderford Dyke Pit at Bradley; near Huddersfield.

A second specimen exhibited by Binney at the same time was referred to *Xylobius sigillariæ*, Dawson. Binney added: "We must expect great additions to be made to the Carboniferous fauna, as doubtless the rich and luxurious vegetation of that remote period would afford food and shelter for numerous insects."

Binney's notes on the Huddersfield specimens caused the Rev. P. B. Brodie to record (1867, 'Geol. Mag.,' vol. iv, pp. 285—286) that he had in his collection "a wing of a gigantic Neuropterous insect in ironstone from the Derbyshire Coal Measures."

The same year Kirkby (1867, 'Geol. Mag.,' vol. iv, pp. 388—390) reported the finding of clearly defined insect-remains in the Durham Coal Measures. One example consisted of "portions of the fore wing or tegmina of an orthopterous insect nearly allied to *Blatta* or Cockroach," and the other "of an orthopterous insect, apparently the abortive wing of a specimen related to the Phasmidæ." Kirkby's first specimen is the small but very fine wing described here under the name of *Phylomylocris mantidioides* (Sternberg). The second specimen is not determinable as an insect-fragment, and may prove to be a fossil fruit, referable to one of the higher plants of the Coal Measures.

From 1867 onwards the finding of fossil insects in the British Coal Measures occurred at long intervals until in 1908, the date of publication of Handlirsch's 'Fossilien Insekten,' the following had been recorded:

Phylomylocris mantidioides (Goldenberg).

olim, "allied to *Blatta*," Kirkby.

olim, "*Blattina mantidioides*,"

Goldenberg.

Lithosialis brongniarti (Mantell).

olim, "*Gryllacris brongniarti*," Mantell.

Lithomantis carbonarius, Woodward.

Archæoptilus ingens, Scudder.

Brodia priscotincta, Scudder.

Ædæophasma anglica, Scudder.

Aphthoroblattina johnsoni (Woodward).

olim, "*Etblattina johnsoni*," Woodward.

(*Blattoidea*) *peachii* (Woodward).

olim, "*Etblattina peachii*," Woodward.

Leptoblattina exilis, Woodward.

Lithomylocris kirkbyi, Woodward.

Soomylacris deanensis (Woodward).

olim, "*Etblattina deanensis*," Woodward.

Pseudofouquea cambrensis (Allen).

olim, "*Fouquea cambrensis*," Allen.

Breyeria woodwardiana (Handlirsch).

olim, "affinity with *Lithomantis carbonarius*,"
Stobbs.

olim, "*Stobbsia woodwardiana*," Handlirsch.

The numerous discoveries of insect-remains in the Coal Measures of Commeny (Allier), France, and the remarkable series made known by Handlirsch from the

continent generally, and from the United States, overshadowed the limited British series, which seemed almost trivial by comparison. The present monograph shows, however, that the fossil insect-remains of the British Coal Measures are far more abundant than was supposed, and that they are by no means unimportant. About seventy specimens are known, of about sixty species, and they represent five of the great groups of fossil insects.

Palæodictyoptera are the dominant forms, and are closely followed by Blattoids, several of which are referable to genera occurring in the French and Belgian coalfields. The British examples of *Soomylacris* are represented near Lens and Liévin by *Soomylacris lievinensis*, Pr., while *Phylomylacris mantidioides* has its counterparts in *Phylomylacris godoni*, Pr., and *Phylomylacris lafittei*, Pr., from Lens. The great Protodonata of Commentry are represented in the Bristol coalfield by *Boltonites radstockensis*.

The generic identity of French and British Coal Measure insects implies that they formed part of a general and wide-spread fauna, a view which is strengthened by the fact that while *Soomylacris deanensis* and *S. stocki* occur in the Forest of Dean coalfield, to the west, *S. burri* occurs in the Kent coalfield to the east, and only separated by the Straits of Dover from the Coal Measures of Northern France, in which Pruvost finds other species of the same genus.

Pruvost has also shown that in the Coal Measures of Lens and Liévin there is present a well-defined horizon of *Anthracomya phillipsii*, in which that species passes through the same developmental changes as in the Kent coalfield.

It is extremely likely that the Kent coalfield will later yield numerous insect-remains closely allied to those of France, and that systematic search will amplify the list of forms already known from all the British coalfields.

The British Palæodictyoptera, on the whole, are more varied than the French, few forms showing the primitive condition of *Stenodictya*, while certain examples, such as *Mecynoptera tuberculata*, *Palæomantis macroptera*, and the three genera of Lithomantids, are highly specialised. A similar degree of specialisation is seen in the British examples of the Protorthoptera, while the Blattoids, by their numerous genera and species, indicate that the group had a long history and a wide geographical range in the British coal period.

The fossil insects already found in the British Coal Measures form probably but a small fraction of those which remain to be discovered when attention is more fully directed to them. The insect-fauna, however, is not usually associated with the general fauna in the Coal Measures, but occurs in beds of lighter coloured rock than the ordinary carbonaceous shales, and with abundant ironstone nodules, or in the case of the Blattoids, in association with masses of drifted vegetation in the black shales, where the venation of the wings so closely simulates the pinnules of *Neuropteris* as to be mistaken for the latter and cast aside.

While insect-remains are usually regarded as wholly restricted to the West-

phalian and Stephanian stages of the Coal Measures, the fauna with which they are most often associated in this country may indicate a greater age, as it is known to occur as low down as the Calciferous Series of Scotland. Any statement, therefore, of the range in time of British Palæozoic insects based on the present known forms may have to be set aside by later discoveries.

The fauna with which fossil insects are usually associated in Great Britain is one in which arachnids and certain of the more primitive arthropods are the dominant forms. Arachnids are known to occur in the Calciferous Sandstone Series of Scotland at Redhall, near Slateford, Edinburgh, and in the Cement-stone Group of the Lower Carboniferous at Langholme, Dumfriesshire (1911, Pocock, 'Mon. Pal. Soc.,' p. 18), and elsewhere, the genus *Archæoctonus* being represented by *A. glaber* and *A. tuberculatus*, and the genus *Cyclophthalmus* by *C. euglyptus* at Redhall, Blair Point, near Dysart, and Cramon near Edinburgh.

No insect-remains are known from any of these horizons, but if the faunal association seen in the Coal Measures is a trustworthy guide, they may be looked for with some prospect of success.

The faunal association existing in the "Scapstone Bed" of the Lower Coal Measures at Carre Heys, Colne, Lancashire (1905, Bolton, 'Geol. Mag.' [5], vol. ii), is so similar in character to the typical insect-fauna elsewhere, that it is likely that insects lived in the Lower Coal Measure period in Lancashire.

This faunal association at Carre Heys is as follows, and may be compared with the faunal association in which insects have been found to occur in other coalfields:

ARTHROPODA.

- Pygocephalus cooperi*, Huxley.
- Anthrapalæmon serratus*, Woodw.
- " *woodwardi*, Etheridge.
- " *traquairi*, Peach.
- Prestwichia rotundata*, Woodw.
- Architarbus subovalis*, Woodw.
- Euphoberia browni*, Woodw.
- Xylobius monilifer*, Woodw.

PISCES.

- Hybodus wardi*, Barkas.
- Acanthodes wardi*, Egerton.
- Elonichthys aitkeni*, Traq.

AMPHIBIA.

- Eugyrinus wildi* (A. S. Woodw.).
- Microsaurian remains.

The oldest known fossil insect in the British Carboniferous appears to be a fragmentary wing (*Genentomum subacutum*), described by the author from shales at a depth of 637 feet below the Bedminster Great Vein in the Bristol Coalfield, and therefore at a considerable depth below the Pennant Grit.

Pseudofouquea cambrensis (Allen) was obtained from the top of the Four-foot Seam in the Lower Coal Measures at the Llanbradach Colliery near Cardiff; while the shales over the No. 2 Rhondda Seam have yielded a wing-fragment of *Boltoniella tenuitegminata* (Bolton); and the shales over the Graigola Seam have yielded the wings of two Blattoids, *Hemimylacris convexa* and *Orthomylacris lanceolata*.

The No. 2 Rhondda Seam and the Graigola or Six-foot Vein of Swansea both occur in the Pennant Grits, the former near the base of the series and the latter at 200 yards below the Swansea Four-foot Seam, which forms the base of the Middle Coal Measures in South Wales.

In Monmouthshire, insect-remains occur in shales over the Mynddislwyn Vein, a seam at the base of the Upper Coal Measures.

The Durham and South Lancashire Coalfields have yielded insect-remains in measures near the top of the Middle Series, while those recorded from the Derbyshire Coalfield are on a still lower horizon in the Middle Series. Few fossil insects are known from the Upper Coal Measures.

HABITS AND MODE OF OCCURRENCE OF FOSSIL INSECTS.

The bodies, and more particularly the wings, of insects, have been entombed in various deposits under conditions difficult to determine. Whatever the conditions, they must have been closely related to the habits of life. The older writers claimed that wind-dispersal and water-carriage were the chief agents. Buckland, for example ('Anniv. Address to the Geol. Soc.,' 1842), supposed "that multitudes of insects have been occasionally drifted by tempests to the sea." Mantell ('Wonders of Geology,' 7th ed., 1857) pointed out that Westwood had drawn attention to the fact that "the streams brought down innumerable insects at certain periods, perhaps those of heavy rain."

Alfred Russel Wallace ('The Geographical Distribution of Animals,' 1876) and Heilprin ('The Distribution of Animals,' 1887) alike drew attention to the widespread occurrence of living insects far out at sea, in some instances still flying strongly. Members of the British Association on their voyage to Australia in 1914 verified these statements by the capture of locusts as their vessel proceeded down the Red Sea and into the Indian Ocean. More than a score of locusts were captured on the vessel by which the writer travelled, and many more must have been driven down into the water by the fringe of a simoon into which the vessel entered beyond Aden.

Many insects are destroyed yearly by falling into streams and rivers after the deposition of their eggs in the water, and by becoming entangled in the surface film.

The occurrence of whole, or almost whole, insects is more likely to furnish surer proof of the conditions under which life was passed than is the occurrence of wings only, because the bodies, being more compact and much heavier than the wings, are less likely to have drifted to great distances. Sometimes, as we shall see later when we consider special cases, such as the Coal Measures of Commeny, France, or the remarkable faunal associations of certain of the British fossil insects,

valuable information is supplied by the deposits, or by the nature of the associated forms of life.

The great group of the Palæodictyoptera and certain of the Protorthoptera and Protodonata had large wings, and were powerful fliers. We should therefore expect to find their remains widely dispersed in deposits of varied nature. This seems to be the case. Compact heavy-bodied insects like the Blattoids would have a more limited range, and their bodies after death could not be carried to great distances. Larval forms would in most cases be included in the deposits in the immediate neighbourhood of the area in which they lived.

M. Henri Fayol, in his description of the Coal Measures of Commeny, France, shows that these deposits were laid down in narrow land-locked lakes of a trough-like form lying in depressions of older schistose and crystalline rocks. The tranquil waters received only the finest mud in suspension, and the resultant mudstones have yielded a large insect-fauna, in which Blattoids are most numerous. The bodies of the insects are preserved in many cases. Certain of the insects were strong fliers, and their occurrence with the bodies intact indicates that they, in all probability, haunted the vicinity of the lakes and flew over them. When strongly-flying insects like *Boltonites radstockensis* or *Lithosialis bronquarti* died upon the land, the wings, because of their membranous and chitinous nature, would persist after the destruction of the softer body, and be swept off into streams after heavy rains or flooding of the land-surface, their great superficial area combined with their lightness making flotation easy.

The transference of insect-wings from the land into water would be accompanied by the drifting of plant-material, and the two would be buried together in the deposit then forming. The wing of *Boltonites* from Radstock was found with plant-remains in deposits of this sort, and may be taken as a proof, supported as it is by other examples of Protodonate wings, that these insects lived over the land and died upon it.

The Palæodictyoptera, with their wings capable only of an up-and-down movement in one plane at right-angles to the body, and, when in a position of rest, disposed straight outwards, are not likely to have frequented the ground, except in the open. These insects, like most of the Palæozoic forms, were all of large size, as contrasted with living types. Pruvost assumes that the characters of the wing unfitted these insects for a forest life, and that they must have been restricted to flight in the open neighbourhood of swamp pools. I do not wholly agree with this assumption, for the branches and leaves of the Coal Measure plants do not seem to have had so great a density and interlacing of foliage as seriously to impede the flight of powerful winged insects. There seems no reason why these insects should not have lived among the brakes of Lepidodendroid and Calamitean trees, and after death fallen or been blown into adjacent waters. The fact that isolated wings are often found in perfect condition and without any signs of wear

and tear such as the wings of aged insects show to-day, raises the question whether in some cases the wings were not shed, as in certain species of recent ants, the shorn insect continuing its life as a ground-feeder.

The Protorthoptera were, judging from the structure of their mouth-parts, somewhat general feeders or carnivorous, and the presence of strong walking legs suggests that they spent much of their life on the ground, possibly along the margins of swamps, where food would be especially abundant. They had, nevertheless, powerful wings, and some members, such as the *Edischiidæ*, had legs adapted for leaping. Orthoptera, represented chiefly by Blattoid forms, were all fitted for flight by means of their large membranous hind-wings, and equally well fitted by powerful walking legs for life on the ground. In repose the hind-wings were hidden under the modified fore-wings.

I have elsewhere given my reason for a belief that the Blattoids were not wholly phytophagous, but in all probability carnivorous also ('Quart. Journ. Geol. Soc.,' vol. lxxvii, p. 153, 1911).

Blattoids may also have entered the water in search of food, for the hind flying wings would be securely protected by the tegmina, whose broad muscular bases of attachment were sufficiently powerful to compress them down on the back and prevent water entering beneath, just as in the case of the living water-beetle, *Hydrophilus piceus*. The chitinous surface of the body and of the tegmina would not hinder progress in water, for their surfaces are no rougher than those of the modern *Dytiscus*, nor would the insect on emerging bring with it so heavy a film of water as to clog its movements. An objection may be found in the presence of stout bristle-like hairs on the legs seen on such forms as *Necynylacris lerichei* (Bolton) (1917, 'Mem. and Proc. Lit. and Phil. Soc. Manchester,' vol. lxi, p. 15), which might conceivably cause air-bubbles to cling in such profusion as to prevent the insect being able to submerge. The presence of fine hairs on the swimming legs of *Hydrophilus* and *Dytiscus* does not hinder the immersion of these insects in water, so that this is not a valid objection. If no hindrance to immersion was caused by the bristle-like hairs, they may have been useful in assisting the act of swimming.

I think the probabilities are in favour of the Blattoids being at least semi-aquatic as well as land insects.

CONDITIONS OF LARVAL INSECT LIFE.

The conditions under which larval life was passed are even more conjectural. The Protodonata may be regarded as insects whose larvæ must have been aquatic, like the aquatic larvæ of the Odonata now living, but Tillyard (1917, 'The Biology of Dragonflies,' Camb. Univ. Press, p. 306) conjectures that since adult Protodonata are found at Commeny without the occurrence of larval forms, the latter

may have dwelt in damp earth rather than in water, and that "the formation of the larval tracheal system undoubtedly proves that this at one time was the case. It may well have been so in Carboniferous times."

Tillyard's views are well worth quoting in full, especially as they support in some measure those of Pruvost: "We may picture to ourselves the giant insects of Commeny as inhabiting the shores of a large, shallow, nearly stagnant lake. In the muddy ooze around its borders grew forests of the Giant Mare's Tail, while further back on the sandy slopes the graceful Cycads and other extraordinary plants formed a more diversified medley. There, amidst rotting vegetation, these insects lived and bred. In such almost amphibious conditions it may well be that the larvæ of *Protephemeroidea* and *Protodonata* first began that series of adaptive changes which finally led them to adopt a purely aquatic mode of life."

The larvæ of *Brodia* and of other forms whose wings I describe under the name of "*Pteronepionites*" must have lived under conditions fitted for their gradual metamorphosis. The body was long, well segmented, and bore rudimentary wings, which were carried well up over the thorax in an erect or semi-erect position. Though rudimentary, the wings possess features which may have determined to a large extent the mode of life. They are attached by broad, strong bases to the thorax, and are very muscular, as shown by the stout ridges proceeding from the point of attachment into the wings, and the anterior margins are also thickened. The bodies with their lateral expansions of the terga are very suggestive of those of the *Diplopoda*, and like them would offer no serious obstacle to progression through rank and rotting vegetation. That these larval insects would also penetrate soft muds, if necessary, in search of food is possible, since the soft-bodied caterpillars of the Hawk-moths of to-day are able to enter hard soil before pupation takes place.

The stout wing-bases and the strengthened margins of the wings would prevent damage to these structures as the larvæ crawled about, or sought to bury themselves in the soil or muds. They were essentially adapted for a ground habit. Whether they were capable of an aquatic or semi-aquatic habit can only be settled by a knowledge of the mode of respiration.

Lubbock, Gegenbaur and others have adduced strong reasons in favour of an aquatic origin of the insects, and in the Carboniferous types we should naturally expect that the original habits had not had time to undergo any great modification. Larval wings of the "*Pteronepionites*" type must have been living structures in which metabolism was active, and very unlike the dried membranous sac-like expansions of the adult insect. The growth of the larval wings was continued throughout metamorphosis, and during this period their delicate nature, broad expanse, and the thinness of the integument may have enabled them to assist in the respiratory function.

The researches of Comstock and Needham show that larval wings of recent

insects receive a plentiful supply of tracheal branches at an early stage, and it is evident that these are much in excess of any aëration the wings are likely to require. The tracheal development seems to be a persistence from an earlier more active condition, when the larval wings may have played a part in assisting the respiration. These considerations, and the presence of spiracle-like structures in the interstitial neurulation of the adult wings of many Palæodictyoptera, lend support to the inference that the wings functioned as organs of respiration. These spiracle-like structures are usually oval or rounded in outline, and thickened. In some instances they show a series of raised lines radiating from the thickened edge into the surrounding areas, as if they had been muscular strands and capable of expansion and contraction.

Are these structures the atrophied remains of spiracles once functional, and fitting the larva for a more or less aquatic existence? During a recent visit to this country Dr. Tillyard has suggested to me that they are rudiments of sensory organs which may have been scent-glands. Scent-glands are known to occur on the wings of many insects, as, for example, the Green-veined White (*Pieris napæ*), the Small White (*Pieris rapæ*) and others, and their appearance is certainly a strong argument in favour of the view. Scent-glands are, however, in all probability but specialised developments of previously existing structures, and it is possible that the glandular-like organs to which I give the name of "pseudo-spiracles," and Handlirsch the name of "pterostigmata," are an earlier development connected with the "tracheoles" of Comstock, or that primary tracheolation to which Tillyard has given the name of "archyodictyon." Tillyard does not accept the view that they had ever any connection with respiration.

The almost total absence of structures which can be accepted as functional gills in these fossil insect-larvæ may be accounted for by the perishable nature of such organs. Before dismissing the question of the respiratory function in its relation to the conditions under which larval life was passed, it is desirable to draw attention to the larval Blattoid, *Leptoblattina exilis*, Woodw. In this insect the abdominal segments have the dorsal hinder margin extended into broad lamellar expansions so filmy in texture that they may have served as organs of aëration. The lamellar expansions were longer in life than they now are, the hinder borders showing an irregular torn edge. Their extreme thinness would permit of a ready osmotic-like action, especially in damp vegetation, or in an aquatic or semi-aquatic habitat. Scudder, Handlirsch, Lane and others are all agreed in the belief that the Blattoids frequented decaying vegetation in or near water, and under these conditions the presence of organs of aëration similar in character to the abdominal expansions of *Leptoblattina exilis* would be of the greatest value and offer no difficulties to the habit of life. No similar structures are known in any other larval Blattoid, so that the view cannot be pressed.

We shall not be far wrong in assuming that the larvæ of some of the Coal Measure insects were wholly aquatic, others semi-aquatic; that the adult Blattoids were indifferently aquatic or terrestrial; the adults of the non-Blattoid types spent most of their life in the vicinity of the swamp-pools in which their larval stages were passed, and to which they might need to return to lay their eggs.

Such a view seems to accord with the known facts, and will explain the special character of the fauna of such deposits as those of Coseley, in Staffordshire, and the brick-clays of Sparth Bottoms, Rochdale, Lancashire. These are evidently true lagoon or swamp-pool deposits as contrasted with the ordinary shales and binds of the Coal Measures.

FOOD OF COAL MEASURE INSECTS.

The nature of the food of Coal Measure insects has been much discussed, as it is so closely associated with habits. Handlirsch considers that the Gymnosperms and Pteridosperms of the Coal Measure forests were not likely to have been frequented by insects in search of food, as these plants do not prove attractive to living insects. Pruvost, on the other hand (1919, ? 1920, "La Faune Continentale du Terrain Houiller du Nord de la France," 'Mém. Carte Géol. France,' pp. 266—267), considers that many members of the Coal Measure flora possessed in their spores, or in the case of the higher plants, in their cones, a plentiful food supply for insects, and he finds in the association of a *Phylloblatta* at Lens with the *Potonica* of *Linopteris* some support for his conclusions.

The contemporaneous rapid development of plants and insects is also quoted by Pruvost in support of his views.

Several writers have argued that the powerful wings and consequent powers of rapid flight of many of the insects are more in accordance with a predatory and carnivorous habit than with a purely frugivorous or herbivorous one, and this belief has led Lameere to write as follows (1917, 'Bull. Soc. Zool. France,' vol. xlii, pp. 36—37): "Over the lake of Commeny flew magnificent Ephemeroptera and splendid Odonatoptera, the carnivorous larvæ of which were aquatic; doubtless the Odonatoptera, when fully grown, devoured the Ephemeroptera, of which the most fully developed types, the Megasecopteridæ, which have left no descendants, must have made great slaughter among the smaller insects.

"On the ground, in the forests, swarmed innumerable Blattoids, which frequented the detritus, and which had as enemies the ferocious and agile Orthoptera, the varied counterparts of our Mantidæ. These latter must have attacked equally the large vegetarian Orthoptera, the counterparts of the Phasmæ, which probably climbed on trees, and the bulky Protohemiptera, which sucked the sap. Some of the Orthoptera jumped, and there were some which by their appearance recall our Acridians, but all these beings were mute.

"Small amphibians, and numerous arachnidians, came to limit the swarm of this articulate world in a country without birds or mammals."

Pruvost does not accept the view of a primitive aquatic origin of insects, but affirms his belief in a terrestrial origin, and thinks that even if an aquatic habit be proved for certain of the larvæ of the Coal Measure insects, the habit must have been secondary, and derived from an earlier land ancestry (*op. cit.*, p. 268).

Scudder has observed in the case of the Blattidæ that the venation of the tegmina very closely resembles the surface-features of the *Neuropteris* pinnule—so strongly in fact as to suggest mimetism.

Pruvost rightly urges that a mimetism is of little value unless the mimetic insect frequents the plant mimicked. At the same time, it can be urged that the stout compact bodies of the fossil Blattoids and their powerful walking legs were equally admirably fitted for progression among rank and decaying vegetation, and that in these conditions the Blattoids were quite as likely to have been omnivorous, while finding some degree of protection among the *Neuropteris* pinnules lying on the ground.

The writer has previously commented on the association of the wings of Blattoids with the leaves of *Cordaites* (1911, 'Quart. Journ. Geol. Soc.', vol. lxxvii, pp. 164—165), and has made the following comment: "While Carboniferous Blattoids may have been wholly phytophagous, it is interesting to note that the leaves of *Cordaites* (in the present case) are impressed with shallow pits, which show faint traces of a spiral. I have in many previous instances found that such pits owed their origin to attached shells of *Spirorbis pusillus*. Whether these leaves were partially submerged in water during life is an open question; but in all cases the plant-tissues of the pittings are depressed, and are accurate impressions of *Spirorbis*. If the Carboniferous Blattoids were not wholly vegetable feeders, the occurrence of *Spirorbis pusillus* upon the *Cordaites* may supply a reason for their frequent association."

CLASSIFICATION.

The classification of fossil insects has presented great difficulties, both to the palæontologist, and to the systematist of living forms. Palæozoic insects show to the systematist a series of forms not strictly referable to any modern grouping, but presenting certain generalised details of structure which link two or more now widely separated groups, besides other features not met with in living forms.

The palæontologist finds that he has not to deal with early and primitive types, followed by a regular series showing a developmental progression, but with an apparent sudden incursion of large series of highly modified and well-developed insects, co-existent with others of more primitive type.

Further discoveries will doubtless do much to eliminate these difficulties, but present knowledge is such that recent entomology helps very little, and the classification of Palæozoic insects must be largely based on the known fossils, realising that many of the intermediate forms are yet unknown.

The classifications of various authors vary widely, and even the broad general facts of relationship are still uncertain. The earliest attempt at a classification of fossil insects appears to have been that of Goldenberg (1873—1877, 'Fauna Saræpontana Fossilis: Die Fossilen Thiere aus der Steinkohlenformation von Saarbrücken.') He recognised a new Order, Palæodictyoptera, for the inclusion of fossil insects differing in structure and the shape of the wings from living representatives of the Orders Neuroptera and Orthoptera, while also possessing characters which seem to link the two orders together. He did not define the order, but arranged it with the other orders as follows:

Order.—PALÆODICTYOPTERA, Goldenb.

Genera.—*Dictyoneura*, Goldenb.; *Eugereon*, Dohrn; *Miamia*, Dana; *Hemeristia*, Dana; *Haplophlebium*, Scudder.

Order.—ORTHOPTERA.

Sub-order.—Orthoptera Pseudo-Neuroptera.

Genera.—*Termes*, Goldenb.; *Termitidium*, Goldenb.

Sub-order.—Orthoptera vera.

Genus.—*Blattina*, Germar.

Order.—RHYNCHOTA.

Sub-order.—Homoptera.

Genus.—*Fulgorina*, Goldenb.

Scudder (1887, article "Insecta," 'Traité de Palæontologie,' by Karl von Zittel, translated by Dr. Charles Barrois, vol. ii, 'Palæozoologie,' pp. 746—833), in his latest classification, considerably extended that of Goldenberg, while retaining the primitive group of the Palæodictyoptera. His complete arrangement is as follows:

A.—PALÆODICTYOPTERA, Goldenberg.

ORTHOPTEROIDEA, Scudder.

Family.—Palæoblattariæ, Scudder.

Sub-family.—Mylacridæ, Scudder.

Genera.—*Mylacris*, Sed.; *Premylacris*, Sed.; *Paramylacris*, Sed.; *Lithomylacris*, Sed.; *Necymylacris*, Sed.

Sub-family.—Blattinariæ, Scudder.

Genera.—*Etblattina*, Sed.; *Spiloblattina*, Sed.; *Archimylacris*, Sed.; *Anthracoblattina*, Sed.; *Gerablattina*, Sed.; *Hermatoblattina*, Sed.; *Progonoblattina*, Sed.; *Oryctoblattina*, Sed.; *Petrablattina*, Sed.; *Poroblattina*, Sed.

Family.—Protophasmidæ, Brong.

Genera.—*Titanophasma*, Brong.; *Litoneura*, Sed.; *Dictyoneura*, Goldenb.; *Poliophtenus*, Sed.; *Archæoptilus*, Sed.; *Protophasma*, Brong.; *Breyeria*, de Borre; *Meganeura*, Brong.; *Ædæophasma*, Sed.; *Goldenbergia*, Sed.; *Haplophlebium*, Sed.; *Paolia*, Smith; *Archegogryllus*, Sed.

NEUROPTEROIDEA, Scudder.

Family.—Palephemeridæ, Scd.

Genus.—*Platephemera*, Scd.

Family.—Homothetidæ, Scd.

Genera.—*Acridites*, Aud.; *Eucænus*, Scd.; *Genopteryx*, Scd.; *Genentomum*, Scd.; *Didymophleps*, Scd.; *Homothetus*, Scd.; *Mixotermes*, Sterzel; *Omalia*, van Ben.

Family.—Palæopterina, Scd.

Genera.—*Miamia*, Scd.; *Dieconeura*, Scd.; *Strephecladus*, Scd.

Family.—Xenoneuridæ, Scd.

Genus.—*Xenoneura*, Scd.

Family.—Hemeristina, Scd.

Genera.—*Lithomantis*, Woodw.; *Lithosialis*, Scd.; *Pachytylepis*, de Borre; *Lithentomum*, Scd.; *Hemeristia*, Dana.

Family.—Gerarina, Scd.

Genera.—*Polyernus*, Scd.; *Gerarus*, Scd.; *Adiphlebia*, Scd.; *Megathentomum*, Scd.

HEMIPTEROIDEA, Scudder.

Genera.—*Eugereon*, Dohrn; *Fulgorina*, Goldenb.

COLEOPTEROIDEA, Scudder.

Palæodictyoptera having a coleopterous aspect indicated by Geinitz and Brongniart.

B.—HETEROMETABOLA, Packard.

ORTHOPTERA, Olivier.

Family.—Forficulariæ, Latreille.

Family.—Blattariæ, Latreille.

Genera.—*Neorthroblattina*, Scd.; *Scutinoblattina*, Scd.; *Blattidium*, Westw.; *Mesoblattina*, Gein.

Family.—Mantidæ, Latreille.

Genus.—*Mantis*, Linné.

Family.—Phasmidæ, Leach.

Genera.—*Agathemera*, Scd.; *Pseudoperla*, Pictet.

Families.—Acridii, Latreille; Locustidæ, Latreille; Gryllidæ, Latreille.

NEUROPTERA, Linné.

Sub-order.—Pseudoneuroptera, Erichson.

Sub-order.—Neuroptera vera.

HEMIPTERA, Linné.

Homoptera, Latreille.

Heteroptera, Latreille.

COLEOPTERA.

C.—METABOLA, Packard.

DIPTERA.

LEPIDOPTERA.

HYMENOPTERA.

A modification of this classification was introduced by Handlirsch, in his "Sub-phylum Insecta" in Eastman's translation of Zittel's 'Text-book of Palæontology,' 1913, as follows:

Class I.—PTERYGOGENEA, Brauer.

Order.—PALÆODICTYOPTERA, Goldenberg.

Families.—Dictyonauridae, Megaptilidae, Hypermegethidae, Lithomantidae, Heolidae, Fouqueidae, Spilapteridae, Lamproptilidae, Polycereagridae, Paolidae.

Order.—MIXOTERMITOIDEA, Handlirsch.

Order.—RECULOIDEA, Handlirsch.

Order.—PROTORTHOPTERA, Handlirsch.

Families.—Spanioideridae, Ischnoneuridae, Caloneuridae, Sthenaropodidae, Edischiidae, Geraridae, Cacurgidae.

Order.—ORTHOPTERA, Olivier.

Sub-order.—Locustioidea, Leach.

Sub-order.—Acridioidea, Handl.

Order.—PHASMOIDEA, Leach.

Order.—DERMAPTERA, De Geer.

Order.—DIPLOGLOSSATA, De Saussure.

Order.—THYSANOPTERA, Haliday.

Order.—PROTOBLATTOIDEA, Handlirsch.

Families.—Stenoneuridae, Protophasmidae, Eoblattinidae, Oryctoblattinidae, Aetophlebidæ, Cheliphlebidæ, Eucænidæ.

Order.—BLATTOIDEA, Handlirsch.

Families.—Spiloblattinidae, Mylacridæ, Poroblattinidae, Neorthroblattinidae, Mesoblattinidae, Pseudomylacridæ, Dictyomylacridæ, Neomylacridæ, Pteridomyacridæ, Idiomylacridæ, Diechoblattinidae, Proteremidæ.

Order.—MANTOIDEA, Handlirsch.

Genus.—*Palæomantis*, Bolton.

Order.—SYPHAROPTEROIDEA, Handlirsch.

Order.—HAPALOPTEROIDEA, Handlirsch.

Order.—PROTOEPHEMEROIDEA, Handlirsch.

Order.—PROTODONATA, Brongniart.

Order.—MEGASECOPTERA, Brongniart.

Order.—PROTOHEMIPTERA, Handlirsch.

The publication of Handlirsch's great work, 'Die Fossilen Insekten,' 1906—1908, marked an important phase in the history of the study of fossil insects. Handlirsch surveyed the whole field of fossil entomology, and brought the great bulk of the known forms under a broad classification. The Order Palæodictyoptera was much extended, defined, and made to include a large series of families, several of which, however, are clearly widely divergent in type. This was soon recognised by other workers, as doubtless by Handlirsch himself, who may have considered it wiser to extend Goldenberg's order, even to the inclusion of forms not definitely related, rather than to formulate a new classification the components of which could not be rigidly defined. Knowing that the field of research was rapidly widening, Handlirsch exercised a wise restraint in not adding a new classification, which could only be of a temporary character. Subsequent events have proved the wisdom of his action. Since 1908, the study of fossil insects has attracted more students, new localities and

insect-horizons have been found, and many new types recorded. Some of these linking forms already known, and others indicate relationships not fully understood. The retention of the Order Palæodictyoptera has therefore resulted in the formation of a somewhat heterogeneous assemblage, all members of which have one point of agreement. They are primitive co-types, more nearly related to each other in various ways than they are to recent insects, although that relationship is not always as demonstrable as one could wish.

The most ambitious classification yet attempted is that of Prof. Lameere (1917, 'Bull. Mus. Hist. Nat., Paris,' no. 1), who has published only a summary of his conclusions. We are not able to determine how valid are his arguments, or if he is justified by evidence in setting forth his new scheme. He sweeps the Order Palæodictyoptera wholly away, pointing out that it consists of a heterogeneous assemblage, and substitutes a more detailed classification as follows:

SUBULICORNIA.

EPHEMEROPTERA.

Family.—Spilapteridæ.

Genera.—*Lamproptilia*, Brong.; *Epitethe*, Handl.; *Becquerelia*, Brong.; *Palæoptilus*, Brong.; *Compsoptera*, Brong.; *Spiloptilus*, Handl.; *Homaloptera*, Brong.; *Graphiptilus*, Brong.; *Spilaptera*, Brong.

Family.—Megasecopteridæ.

Genera.—*Aspidothorax*, Brong.; *Corydaloides*, Brong.; *Diaphanoptera*, Brong.; *Cycloscelis*, Brong.; *Sphecoptera*, Brong.; *Psilothorax*, Brong.; *Mischoptera*, Brong.; *Ischnoptilus*, Brong.

Family.—Protephemeridæ.

Genera.—*Apopappus*, Handl.; *Triplosoba*, Handl.

ODONATOPTERA.

Family.—Fouqueidæ.

Genera.—*Fouquea*, Brong.; *Rhabdoptilus*, Brong.

Family.—Dictyoneuridæ.

Genera.—*Microdictya*, Brong.; *Stenodictya*, Brong.

Family.—Dictyoptilidæ (Protodonata).

Genera.—*Archæomegaptilus*, Brong.; *Dictyoptilus*, Brong.; *Poromaptera*, Brong.; *Protagrion*, Brong.; *Gilsonia*, Brong.; *Meganeura*, Brong.

RHYNCHOTA.

PROTOHEMIPTERA.

Family.—Homoiopteridæ.

Genera.—*Lycocercus*, Handl.; *Homoioptera*, Brong.; *Lithoptilus*, Brong.

Family.—Megaptilidæ.

Genus.—*Megaptilus*, Brong.

Family.—Breyeridæ.

Genus.—*Megaptiloides*, Handl.; *Borrea*, Brong.

Family.—Mecynostomidæ.

Genus.—*Mecynostoma*, Brong.

HEMIPTERA.

Family.—Dictyocicadidæ.

Genus.—*Dictyocicada*, Brong.

ORTHOPTERA.

Nomoneura (Blattæformia, Handl.).

(a) Blattoidea.

Families.—Hyaloptilidæ, Protoperlidæ, Fayoliellidæ, Oryctoblattinidæ.

(b) Mantoidea.

Families.—Stenoneuritidæ, Stenoneuridæ, Ischnoneuridæ.

Heteroneura. (Equivalent in part to Orthoptera Cursoria and Orthopteroidea, Handl.)

(a) Phasmoidea.

Family.—Sthenaropodidæ.

(b) Locustidæ. (Equivalent in part to Orthoptera Saltatoria.)

Families.—Ædischiidæ, Caloneuridæ.

Lameere restricted his research to the French fossil insects, his studies being based on the types described and figured by Brongniart (1893, 'Bull. Soc. Industrie, Saint Etienne,' 3 sér., vii), the collections made by Fayol, and the large series of fossil insects from the Upper Coal Measures (Stephanian) of Commentry, now preserved in the National Museum of Natural History, Paris. The following remarks may be made on his classification:

EPHEMEROPTERA.—The three families forming this division are regarded as closely related, the genus *Becquerelia* of the Spilapteridæ bearing certain characters of the Megasecopteridæ, while the family is also linked through the genus *Apopappus* (which is taken to supply a natural transition between the Spilapteridæ) to the genus *Triplosoba*.

ODONATOPTERA.—The family Fouqueidæ is held to differ from the Spilapteridæ in that transverse veins are numerous, close together, and form a network over the inner margin, and in the anal area—a feature which brings it nearer to the Protodonata. The family Dictyoneuridæ possesses a network of veins extending over the whole wing, as in *Microdictya*. The remaining family, Dictyoptilidæ, contains *Archæmegaptilus*, which Lameere considers differs only from the Dictyoneuridæ in the fusion of the median and radial veins at the base of the wing. *Protagrion* is considered nearest to the true Odonata, while *Meganeura* and *Gilsonia* are specialised types.

RHYNCHOTA.—The presence of a rostrum in *Lycocercus goldenbergi*, and the resemblance of the head and leg of *Homioiptera gigantea* to the same structures in *Eugereon*, are considered sufficient proof of the Protohemipteroid characters of *Lycercus*, *Homioiptera*, and the allied genera *Lithoptilus*, *Megaptilus*, *Mecynostoma*, *Archæoptilus* and *Paramegaptilus*.

ORTHOPTERA.—Lameere regards Handlirsch's group of Protorthoptera as an assemblage of two related but distinct types, which he classifies under *Nomoneura* and *Heteroneura*. The genus *Stenoneurites* is regarded as the connecting link between the Mantoidea and the ancestors of the Blattoidea, the genus *Stenoneura* being also in some measure transitional between *Stenoneurites* and the Ischnoneuridæ.

Nomoneura.—This sub-division includes the *Blattæformia* of Handlirsch, and is distinguished by the wings having no precostal area, as contrasted with a second division, *Heteroneura*, in which a precostal area is present, and in which the legs are adapted for running and jumping. The *Nomoneura* include forms classified by Handlirsch under the *Protorthoptera* and *Protoblattoidea*. Lameere separates his *Nomoneura* into (*a*) *Blattoidea*, and (*b*) *Mantoidea*, the former characterised by a sub-costal which joins the outer or costal margin, a more or less lengthened radius, and a small cubitus. The *Mantoidea* have the sub-costa joining the radius, and a large preponderating cubitus.

Heteroneura.—This sub-division includes the *Phasmoidea* and the *Locustoidea*, the former containing the family (*a*) *Sthenaropodidæ*, in which the legs are long and stout, the head prognathous, the prothorax long and narrow in front and very wide behind, and presenting two dorsal expansions.

The wing-venation of the *Sthenaropodidæ* is such that they may have been the ancestors of the *Phasmidæ*. Lameere, however, does not regard the *Sthenaropodidæ* as ancestors of the *Phasmidæ*, but as arising with them from a common ancestor.

The members of the families (*Edischiidæ* and *Caloneuridæ* possess legs fitted for jumping, but differ considerably in their wing-venation. The *Edischiidæ* are possibly linked with the *Locustidæ*, and the *Caloneuridæ* with the *Acrididæ*.

Circumstantial and detailed as Prof. Lameere's classification is, the arguments and deductions are not easily followed, the paper being only in abstract. A study of the fossil insect-material from Commeny alone is not in itself likely to yield all the facts and premisses upon which a classification can be built applicable to the Palæozoic insect-fauna of all coalfields and countries. Much more evidence is wanted, and until the full paper is published, it is necessary to hold the classification in suspense.

The most recent publication on the Palæozoic insects is an extensive and valuable memoir by Dr. P. Pruvost (1920, "La Faune Continentale du Terrain Houiller du Nord de la France," 'Mémoires pour servir à l'Explication de la Carte Géologique détaillée de la France,' Paris, 1920) on the fossil insects recently found by him, and others, in the neighbourhood of Lens and Liévin in the north of France. Dr. Pruvost adopts the classification of Handlirsch with few emendations as follows, and by his new material he has added considerably to our knowledge of the *Protoblattoidea* and *Blattoidea*:

Order.—*PALEODICTYOPTERA*.

Family.—*Stenodictyopteridæ*, Brong. (*Dictyoneuridæ*, Handlirsch).

Family.—*Spilapteridæ*, Brong., emend. Handlirsch.

Order.—*PROTORTHOPTERA*, Handlirsch.

Families.—(*Edischiidæ*, *Caloneuridæ*).

Order.—*HAPALOPTEROIDEA*, Handlirsch.

Family.—*Hapalopteridæ*.

Order.—PROTOBLATTOIDEA, Handlirsch, emend. Pruvost.

Sub-order.—Archiblattidæ, Pruvost.

Family.—Cacurgidæ, Handl.

Sub order.—Archimantidæ, Pruvost.

Family.—Cymenophlebidæ, Pruvost.

Order.—BLATTOIDEA, Handlirsch.

Family.—Archimylacridæ, Handl.

Genera.—*Archimylacris*, *Asemoblatta*, *Manoblatta*, *Actinoblatta*, *Phyloblatta*, *Archæotiphe*, *Barroisiblatta*, *Grypoblatta*, *Mesitoblatta*.

Family.—Mylacridæ, Sed.

Genera.—*Hemimylacris*, *Phylomylacris*, *Trilophomylacris*, *Soomylacris*, *Orthomylacris*, *Stenomylacris*, and *Lithomylacris*.

Family.—Poroblattinidæ, Handl.

Genus.—*Premnoblatta*, Pruv.

I have compared notes with M. Pruvost, and we have arrived independently at the conclusion that for the present the classification of Handlirsch is, with few emendations, the best to adopt, and most in keeping with the known facts.

FAUNAL ASSOCIATION.

Various collectors in British Coalfields have discovered not only insect-remains, but a definite faunal association, of which the significance seems to have been overlooked, and it has therefore not received the attention it deserves.

Most of the insect-remains are found in ironstone nodules, and the beds in which these nodules occur are usually light-coloured rocks more similar to hardened clay than to normal shales. The nodules are in vast numbers, ranging in size from half-an-inch to ten and twelve inches in diameter. The beds seem more comparable to the fireclays or seat-earths than to the ordinary fissile shales, and both in lithological character and fossil contents stand in some measure apart from the ordinary Coal Measure rocks. They are not restricted to one coalfield, but have a wide distribution. Where a systematic search of beds of this character has been made, the insect-remains have been found accompanied by a fauna in which arthropods of a more primitive type than insects are conspicuous.

The character of this fauna will be best understood by reference to the following lists of fossils which have been recorded from certain localities:

DURHAM COALFIELD.—“Zone of *Anthracomya phillipsii* (Will.)” in upper part of the Middle Coal Measures; Claxheugh escarpment, two miles west of Sunderland, Durham.

PELECYPODA.

“*Ancylus vinti*, Kirkby ” (cf. “*Spat*” of *Anthracomya phillipsii*, Will.).

Anthracomya minima (Ludvig). *A. lævis*, var. *scotica*.

MEROSTOMATA.

Belinurus trechmanni (Woodw.):

DIPLOPODA.

Euphoberia, sp.

OSTRACODA.

Beyrichia, McCoy.*Cythere* or *Cypris*.

INSECTA.

Lithomyllacris kirkbyi, Woodward.*Phylomyllacris mantidioides* (Goldenberg).

PISCES.

Rhizodopsis sauroides (Will.).

NOTTINGHAM AND DERBYSHIRE COALFIELD.—Below the Top Hard Coal, Middle Coal Measures (1911, Moysey, 'Geol. Mag.' [5], vol. viii, p. 506); Shipley Manor clay-pit, one and a half miles north of Ilkeston, Derbyshire.

ANNELIDA.

Spirorbis, sp.

PELECYPODA.

Authracomya modiolaris (Sow.).*Carbonicola aquilina* (Sow.).*Naiadites modiolaris* (Sow.).

OSTRACODA.

Beyrichia arcuata? (Bean).*Estheria*, sp.*Leaia trigonioides*, Moysey.

CRUSTACEA.

Preanaspides praeursor, Woodw.*Arthropleura armata*, Jordan.

" sp. nov., Moysey.

ARACHNIDA.

Cyclus, sp." *johnsoni*, Woodw.*Belinurus bellulus*, König." *königianus*, Woodw." *longicaudatus*, Woodw.

" sp.

Prestwichia anthrax (Prestw.)." *birtwelli*, Woodw." *rotundata* (Prestw.).

" sp.

Eurypterus derbiensis, Woodw.

ARACHNIDA—(continued).

Eurypterus moyseyi, Woodw.

Scorpion, post-abdominal segment, Moysey.

Geralinura britannica, Pocock.*Eobuthus holti*, Pocock.*Anthracosiro fritschi*, Pocock." *woodwardi*, Pocock.

" sp.

Protolycosa, sp.

INSECTA.

Cryptovenia moyseyi, Bolton.*Orthocosta splendens*, Bolton.*Pteronidia plicatula*, Bolton.

PISCES.

Elonichthys, sp.

EGG CAPSULES OF FISHES (?).

Fayolia crenulata, Moysey." cf. *dentata*, Zeiller.*Palaeoxyris carbonarius* (Schimper)." *helicteroides* (Morris)." *prendeli*, Lesq.*Vetacapsula johnsoni* (Kidston)." *cooperi*, Mackie and Crocker.

PLANT REMAINS.

Annularia; *Calamocladus*; *Sphenophyllum*;*Lepidophyllum*; *Calamites*; ferns.

LANCASHIRE COALFIELD.—Greyish-blue shales, 135—180 feet above the Royley or Arley mine, the latter at the base of the Middle Coal Measures; Sparth Bottoms, Rochdale, Lancashire. I am indebted for the following list to Mr. Walter Baldwin, F.G.S., who, with Messrs. Sutcliffe, Parker, Platt and others, has devoted years to the examination of these beds.

VERMES.

Spirorbis (*Spirogyphus*).

BRACHIOPODA.

Lingula, sp.

PELECYPODA.

Carbonicola acuta (Sow.)." *robusta* (Sow.)." *turgida* (Brown).

PELECYPODA—(continued).

- Naiadites modiolaris* (Sow.).
 „ *triangularis* (Sow.).
 „ *carinata* (Sow.).
 „ *elongata* (Hind).
Anthracomya williamsoni (Brown).

EUCRUSTACEA.

- Dithyrocaris*, sp.
Pygocephalus cooperi, Huxley.
 „ (? *Anthropalæmon*) *parkeri*
 (Woodw.).

Anthropalæmon grossarti, Salter.

Eurypterus, sp.

Cyclus johnsoni, Woodw.

Rochdalia parkeri, Woodw.

Belinurus lunatus (Martin).

„ *königianus*, Woodw.

„ *baldwini*, Woodw.

„ *longicaudatus*, Woodw.

„ *testudineus* (Woodw.).

ARACHNIDA.

- Prestwichia birtwelli*, Woodw.
 „ *rotundata* (Prestwich).
 „ „ var. *major*, Woodw.
 „ „ „ *minor*, Woodw.
 „ (*Euproöps*) *danæ*, Meek & Worthen.
 „ *anthrax* (Prestwich).
Eoscorpium (*Mazonia*) *wardingleyi*, Woodw.
Eobuthus holti, Pocock.

ARACHNIDA—(continued).

- Anthracoscorpium buthiformis*, Pocock.
 „ *sparthensis*, Pocock.
Geralinura sutcliffei, Woodw.
Anthracomartus trilobitus, Scudder.
 „ sp. 1 in Platt Coll.
 „ sp. 2 in Platt Coll.
Anthracosiro woodwardi, Pocock.
Phalangiotarbus subovalis (Woodw.).
 „ (*Architarbus*) *rotundata*,
 Woodw.

DIPLOPODA.

- Xylobius platti*, Woodw.
Euphoberia ferox, Salter.
 „ *armigera* (Baldwin)
 „ *robusta* (Baldwin).
 „ *woodwardi* (Baldwin).
Archiulus, sp.
Acantherpestes major, Meek & Worthen.
 „ *giganteus*, Baldwin.

INSECTA.

- Spilaptera sutcliffei*, Bolton.
Mecynoptera tuberculata, Bolton.

PISCES.

- Platysomus tenuistriatus*, Traquair.
Rhizodopsis sauroides (Will.).

INCERTÆ SEDIS.

- Palæoxyris prendeli*, Lesq.

SOUTH STAFFORDSHIRE COALFIELD.—Binds between the “Brooch” and “Thick” coals; Tipton, Dudley, and Coseley.

EUCRUSTACEA.

- Euphoberia ferox*, Salter.

ARACHNIDA.

- Anthracoscorpium buthiformis*, Pocock.
Geralinura britannica, Pocock.
Græophonus anglicus, Pocock.
Eotheniza silvicola, Pocock.
Archæometa nephilina, Pocock.
Curculioides antsticii, Buckland.
Poliochera alticeps, Pocock.
Plesiro madeleyi, Pocock.
Geraphrynus angulatus, Pocock.
 „ *hindi*, Pocock.
 „ *tuberculatus*, Pocock.
 „ *eggintoni*, Pocock.
 „ *torpedo*, Pocock.

ARACHNIDA—(continued).

- Geraphrynus angustus*, Pocock.
Anthracomartus hindi, Pocock.
 „ *priestii*, Pocock.
Anthracosiro woodwardi, Pocock.
 „ *fritschii*, Pocock.
Trigonotarbus johnsoni, Pocock.

INSECTA.

Palæodictyoptera.

- Pruvostia spectabilis*, Bolton.
Brodia priscotineta, Scudder.
 „ *furcata* (Handl.).
 “*Pteroneptonites*” *lepus*, Bolton.
 „ *ambiguus*, Bolton.
Geroneura (?) *ovata*, Bolton.

INSECTA—(continued).

Protorthoptera.

Xeroptera obtusata, Bolton.*Scalæoptera recta*, Bolton.*Coselia palmiformis*, Bolton.

Blattoidea.

Aphthoroblattina johnsoni (Woodw.).

COALBROOKDALE COALFIELD, SHROPSHIRE.—Ironstone Nodules of the Pennystone Series.

EUCRUSTACEA.

Enphoberia ferox, Salter.*Anthraxpæmon (Apus) dubius* (Prestw.).

ARACHNIDA.

Prestwichia anthrax (Prestw.).,, *rotundata* (Prestw.),, *trilobitoides*, Woodw.

INSECTA—(continued).

Blattoidea—(continued).

Aphthoroblattina eggintoni (Bolton).*Archimyrlacris incisa* (Bolton).*Phylloblatta transversalis* (Bolton).

LARVAL BLATTOID.

Leptoblattina exilis, Woodw.

ARACHNIDA—(continued).

Curculioides ansticii, Buckland.*Eophrynus prestvici* (Buckland).

DIPLOPODA.

Acantherpestes brodiei, Scd.

INSECTA.

Lithosialis brongniarti (Mantell).

SOUTH WALES COALFIELD.—Shales in the neighbourhood of the Mynddislwyn Vein, base of the Upper Coal Measures.

ARACHNIDA.

Aphantomartus areolatus, Pocock.*Græophonus anglicus*, Pocock.*Maiocercus celticus*, Pocock.*Kreischeria verrucosa*, Pocock.

INSECTA.

Aphthoroblattina sulcata (Bolton).*Orthomyrlacris lanceolata* (Bolton).*Archimyrlacris hastata* (Bolton).,, *obovata* (Bolton).

The arthropod association in the lists given is significant, for no other animals enumerated are so readily water-borne as are insects. It may be assumed that neither the more primitive arthropods, nor the insects, have been transported to any great distance from their former habitat. Their preservation under similar conditions supports the belief that their habits and habitats were the same, or closely approximated to the same conditions of entombment.

The freedom of the deposits from comminuted carbonaceous matter, such as is usually a chief constituent of the Coal Shales, may be accounted for by the beds having been laid down in quiet lagoons or swamp lakes, into which only the finer mud particles and floating pinnules and *débris* of coal-plants could pass and accumulate. Such waters were probably fresh or brackish, shallow, and limited in area. As we have indicated elsewhere (p. 10), it has been considered that the larvæ of many of the Coal Measure insects were semi- or wholly aquatic, and if such was the case, they would be more likely to be found in the deposits accumulating in quiet waters than in others exposed to movement. The presence of Mollusca and the lower orders of Arthropoda, with such forms as *Palæoxyris*, and even fish-remains, can be accounted for by the existence of occasional or permanent passages leading to open waters, such as river channels and the open sea.

A succession of such lagunal lakes or swamp pools might be seasonal features along a depression which, in a wet season, formed a water-course.

The paucity of Mollusca is noteworthy, only one species (" *Unio* ") having been recorded by Moysey, notwithstanding his careful search of material from the Shipley clay-pit at Ilkeston, Derbyshire; while Kirkby, and more recently Trechmann and Woolacott have recorded *Anthracomya phillipsii*, in addition to "*Ancylus vinti*" (now known to be the larval form of *A. phillipsii*), from the insect-bearing beds at Claxheugh, near Sunderland.

The deposits at Sparth Bottoms, Rochdale, Lancashire, are remarkable in that they have yielded three species of *Carbonicola*, four species of *Naiadites*, and one species of *Anthracomya*.

In regard to the presence of Crustacea, Thomson (1894, 'Trans. Linn. Soc. London,' Zoology [2], vol. vi, p. 3), has shown that the recent *Anaspides tasmaniae* lives in freshwater pools and lakes which are wholly cut off from the sea, and Dr. H. Woodward (1908, 'Geol. Mag.' [5] vol. v, p. 385) has described an allied form, *Preanaspides præcursor*, from the Coal Measures of Shipley Clay-pit. Further research may prove that not only *Preanaspides*, but such forms as *Belinurus*, *Prestwichia*, *Eurypterus* and *Anthrapalæmon* were also fresh-water in habit, co-existing with insect larvæ in the lagoons and swamp lakes.

Observations by the writer during the visit of the British Association to Australia in 1914 bear on this point. While collecting in the "Bush country" at St. Margaret's Bay, Western Australia, at Warburton, S. Australia, and elsewhere, examination of almost every loose sheet of bark hanging to the gum trees revealed a colony of scorpions, millipedes, spiders and cockroaches. In the Australian localities mentioned true "bush" conditions prevailed, and seemed much unlike those of low-lying swamps, such as are predicated for the Coal Measure period. Subsequent experiences along the coast of North Queensland modified these first impressions. It was found that notwithstanding the hot tropical day, or perhaps by reason of it, the nights brought an extremely heavy dew, so that it was impossible to move four yards in the jungle before the clothing was running with water discharged from the leaves of the jungle plants. In a short time after sunrise the jungle was dry again, but much of the moisture must have been caught up under projections capable of resisting the penetration of the sun's heat. In the "bush" country, slabs of bark may give conditions which the arthropod fauna find the most tolerable during the hot season. The Australian winter with its heavy rains would more nearly accord with swamp conditions. Long stretches of the coastline of Queensland, north of Brisbane, the country along the Hinchinbrooke Channel, and in the neighbourhood of Townsville, are low-lying, and covered by dense mangrove swamps growing out into the sea and completely hiding the outlets of rivers.

The conditions seem similar to those of the low-level country, swamp and

mud flat upon which the coal forests are believed to have flourished. During the voyage along the coast, a landing was made at Lucinda Point, and an opportunity was afforded of entering the swamp. Part of the swamp was awash on landing, but as the tide receded, it was possible to reach the shore. The latter was found to be a flat shelving beach, consisting of fine marine sand on the seaward side, passing shorewards into a fine tenacious clayey mud in which the mangroves grew. The sand bore numerous remains of echini, mollusca and marine *débris*, while the mud below high-water mark and above it was penetrated in all directions by the roots of mangroves, by the burrows of crabs, and by a burrowing gasteropod, *Telescopium fuscum*.

Masses of leaves, branches and other vegetable material were mixed with the mud, the latter in some places forming irregular lumps and boulder-like masses around the vegetable material. A broad shallow depression, with a few inches of water over a thick bed of mud littered with leaves, led into the swamp. It was evidently the bed of a stream during the wet season, remaining as a series of disconnected pools at other times, or drying up.

The resemblance of the physical conditions to those accepted as dominant in the Coal Measure period was so evident that special attention was given to it with a view to discovering discrepancies; yet, had the mangroves been replaced by dense groves of gum trees with their arthropod fauna, the circumstances would have been well-nigh identical. Had the faunal association of scorpions, millipedes, spiders and cockroaches of West Australia been transported to the swamp, their remains would have become entombed in material not unlike that at Sparth Bottoms or Coseley.

There is ample evidence to show that the coal plants grew on ground of this character, and we know that the remains of fossil insects are associated with the plant-remains.

The swamp conditions of the North Queensland coast reproduce with great exactitude the presumed Coal Measure conditions, but lack the arthropod fauna owing to the unsuitability of the vegetation.

Scudder had some such habitat and faunal association in mind when writing his work "Archipolypoda: a Sub-ordinal Type of Spined Myriapods from the Carboniferous Formation" ('Mem. Boston Soc. Nat. Hist.,' vol. iii, no. 5, pp. 143—182). Plate X of that work is described as "an attempted restoration of a specimen of *Acantherpestes major*, Scd." The specimen is represented as leaving the water, in which the hinder part of the body is still swimming by means of its legs, while the fore part of the body is creeping up the trunk of a *Lepidodendron* (*L. vestitum*). On the trunk crawls a cockroach (*Etolblattina mazona*, Scd.); and a broken stem of *Calamites cistii*, Brong., lies partly fallen in a clump of *Neuropteris laesclii*, Lesq.

We are, therefore, not without some justification in assuming that the faunal

association which exists at Coseley, Sparth Bottoms, and elsewhere is not due to the accident of deposition or transportation, but the natural result of the conditions under which insect life was passed.

SYSTEMATIC DESCRIPTIONS.

Order *PALÆODICTYOPTERA* (Goldenberg), Handlirsch.

1877. Goldenberg, Die Fossilen Thiere aus der Steinkohlenformation von Saarbrücken. Fauna Saræpontana Fossilis, pt. ii, p. 8.

1906. Handlirsch, Die Fossilen Insekten, p. 61.

Slender insects with moderate-sized head and biting jaws, simple antennæ, and two pairs of equal and similarly shaped wings. The wing-venation is not unlike the hypothetical tracheation of the primitive nymph worked out by Comstock and Needham ('American Naturalist,' vol. xxxii, no. 374, p. 85, fig. 4, 1898—99).

The wings could not be folded, being outstretched laterally in the position of rest, and only moving in a vertical plane at right-angles to the body. The thoracic segments are three in number, with wing-like pleurites in some cases on the first segment. The abdomen has eleven segments, the eleventh segment bearing cerci. Legs all similar, and fitted for running.

Goldenberg did not define the characters of the Order, but included in it a group of Palæozoic insects which, while somewhat related to the existing forms of Neuroptera, are sufficiently unlike to prevent their inclusion in the latter Order.

Handlirsch defined the Order as a primitive generalised group, probably the ancestors of all later insects, and wholly confined to the Palæozoic. He considered that the larvæ were predatory and aquatic, developing their wings gradually without resting stages, and being in other respects similar to the imago. His diagram of the primitive Palæodictyopteroid wing shows a slight advance upon the primitive nymph of Comstock and Needham, the primary tracheation being increased by the development of cross-nervures, uniting to form a meshwork.

Family *DICTYONEURIDE*, Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 63.

1919. Handlirsch, Revision der Paläozoischen Insekten, p. 3.

Palæozoic insects in which the wings possess a close reticulated neuration between the principal veins, the latter strong and parallel over the first third of the wing. Branches of the radial sector, median and cubitus few in number, and strongly curved back to the inner margin.

Handlirsch regards this family as closely related to *Microdictya*.

Genus **DICTYONEURA**, Goldenberg.

1854. *Dictyoneura*, Goldenberg, Palæontographica, vol. iv, p. 33.

Wing three times as long as wide. Base narrow, outer margin curving regularly backwards beyond the middle of the wing into the wing-apex. Inner margin rounded, and joining the apex in a blunt curve. Subcosta straight, reaching the costal border in the outer third of the wing. Radius simple, parallel to subcosta, and giving off a radial sector with few branches. Hinder branch of median and first branch of cubitus uniting to form a "cubito-median Y-vein." Anal veins with few branches. Interstitial neuration irregularly reticulate.

Dictyoneura higginsii (Handlirsch). Plate I, fig. 1.

1871. "Neuropterous Insect-Wing," Higgins, Proc. Liverpool Nat. Field Club, vol. ii, p. 18, fig. 15.

1906. (*Palæodictyopteron*) *higginsii*, Handlirsch, Foss. Insekt., p. 125, pl. xiii, fig. 6.

1917. (*Dictyoneuron*) *higginsii*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 46, pl. iii, fig. 2.

1919. *Sherborniella higginsii*, Handlirsch, Revis. Paläozoischen Insekten, p. 25.

Type.—Basal portion of a left wing in counterpart; Liverpool Museum.

Horizon and Locality.—Middle Coal Measures; Ravenhead railway cutting, near St. Helens, Lancashire.

Description.—The wing-fragment lies on the surface of a greyish-purple ironstone nodule, and has a length of 32 mm., with a greatest width of 22 mm. The total length and width cannot be exactly estimated.

Handlirsch, who named the species, did not describe it, and it is doubtful if he ever saw it. It was first described by the late Rev. H. H. Higgins thus: "A second and smaller specimen of insect wing was obtained by myself, and referred to the genus *Corydalus*. Mr. J. P. G. Smith compared it with *Fulgora*. A slight sketch of it was seen by Mr. F. Smith, of the British Museum, whom it reminded of *Gryllotalpa*. Mr. Benj. Cooke, of Manchester, after a careful examination, says, 'I believe the fossil represents the basal portion, about one-third only, of the forewing of a *Chrysopa*, Goldeneye, or Lace-wing fly, or rather *Nothochrysa*, separated from *Chrysopa* by Mr. McLachlan on account of the manner in which the third cubital cell is divided.' This cell is remarkably well shown in the fossil, and though I could only judge from memory, I believe it is sufficient to settle its relationship."

The "cubital cell" mentioned by Mr. Benj. Cooke is an elongated area enclosed by a union of two of the main veins in the base of the wing. The identity of the veins enclosing the "cell" will be considered later.

The costal border is preserved for a length of 29 mm., is strongly curved proximally and less so distally. It would seem to have been directed somewhat

backwards in its course to the wing-apex. The intercostal area is very wide at the base, and diminishes in diameter towards the wing-apex, but it is doubtful if it reached the latter.

The subcosta is straight, but not well defined. The radius is fairly parallel to the subcosta and gives off the radial sector low down in the base of the wing; the radial sector comes off from the radius at an acute angle, and keeps parallel with it as far as preserved. Its direction is such that it must have reached the wing-apex. The median and cubital veins merit special consideration. In the specimen three veins occupy the position of the normal median and cubitus. Of these, two either arise from a common root, or so close together as to be indistinguishable, the third having a separate origin. The innermost of the three sends off from near its base a forwardly directed twig, which joins the second of the two outer veins.

It is necessary to resolve these veins into median and cubitus. To do this we must consider recent research on living insects. Comstock and Needham concluded that the primitive median vein was a four-branched structure; more recently Tillyard, from further studies of the wing-venation of recent nymphs, concludes that the primitive median had an initial dichotomy, of which the outer branch divided up into four ("M" of Tillyard, 'Proc. Linn. Soc. N.S. Wales,' vol. xliv, 1919, p. 552), and the second branch remained simple. Comstock and Needham concluded that the primitive cubitus was two-branched; Tillyard considers it (*loc. cit.*, p. 553) as three-branched, the outer or first branch having a distal forking into two feeble twigs, and an inner feeble branch which remains simple. The primary cubital fork is situated near the base of the wing.

Tillyard's views are not very different from those of Comstock and Needham, as he admits a basal fork of the cubitus, but adds a secondary forking of the end of the outer branch.

Tillyard has studied the relation of the two veins in the various Orders, and finds that the "posterior arculus" of Comstock, which is supposed to be a cross-vein from the median to the cubitus, is, as shown in the fossil Order *Paramecoptera*, not a cross-vein, but a true branch of the median. The various stages by which the connection becomes established and afterwards developed into a combined vein from the point of union, are fully stated (*loc. cit.*, p. 357), and the compound vein is named the "cubito-median Y-vein." An examination of the conditions observable in *Dictyoneura higginsii* shows that the united veins and their single-stemmed prolongation are in position and character identical with Tillyard's "cubito-median Y-vein." The three veins of the specimen, therefore, are the outer median vein, the inner median uniting with the first cubital vein, to form a "cubito-median Y-vein," and lastly, the second (inner) branch of the cubitus.

Tillyard recognises the presence of the "cubito-median Y-vein" in the Permian Order *Paramecoptera*, but its discovery in the Coal Measure genus *Dictyoneura*

shows that its origin is of much older date. The cubito-median Y-vein lies close to the outer median for a short distance, and then bends obliquely inwards to the margin of the wing. The inner cubital vein is fairly straight, and widely spaced along almost its whole length from the cubito-median Y-vein.

Six anal veins are present, all going obliquely to the inner margin, the second and third alone forking. The interstitial neuration, which I have been able to study better by immersing the specimen in water, consists of numerous irregular cross-nervures, occasionally uniting in crossing, or forming a loose meshwork, especially between the median and cubital veins.

Affinities.—With so small a wing-fragment, and with few wings of similar character as guides, it is not possible to form an accurate idea of the whole wing. The radius and radial sector entered the wing-apex, and the median-cubital elements occupied the greater part of the inner margin of the wing.

The broad intercostal space and the course of the subcosta are very similar to those in *Polycyrea elegans*, Handlirsch, but the general trend of the main veins, and most of all the character of the interstitial neuration, are so suggestive of *Dictyoneura libelluloides*, Goldenberg, that I had referred the specimen to that genus before Handlirsch's paper was published.

Handlirsch has now (1919) referred this species to a new genus, *Sherborniella*, giving the new name "for the sake of uniformity," but without diagnosis.

Family ORTHOCOSTIDÆ, Bolton.

1912. Bolton, Quart. Journ. Geol. Soc., vol. lxxviii, p. 313.

Wings with almost straight outer margin; inner margin well rounded; costa, subcosta and radius closely approximated; median, cubitus and anal veins occupying nearly the whole of the inner half of the wing.

Genus ORTHOCOSTA, Bolton.

1912. *Orthocosta*, Bolton, *loc. cit.*, p. 313.

Generic Characters.—Radial sector diverging from radius, and with few divisions. Median with two branches united by a commissure. Cubitus stout, forked near base, the outer branch forking twice, and the inner once. Anal area elliptical. Interstitial neuration forming an open polygonal meshwork.

Orthocosta splendens, Bolton. Plate I, fig. 2; Text-figure 1.

1912. *Orthocosta splendens*, Bolton, Quart. Journ. Geol. Soc., vol. lxxviii, p. 310, pl. xxxi, figs. 1—3.

Type.—Incomplete wing, and impression; Moysey Collection, Museum of Practical Geology, Jermyn Street (nos. 30,222 and 30,223).

Horizon and Locality.—Middle Coal Measures (below the Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire.

Specific Characters.—Radial sector reaching the inner half of the wing-tip. Outer branch of median four or five times divided, inner branch simpler and forked. Cubitus dividing low down, the outer branch the stronger, and each doubly forked. Anal veins one or two in number, alternately branched.

Description.—The species is founded on a wing-fragment, the apex, a portion of the inner margin, and the base being incomplete. The total length is 84 mm., the width 33 mm. The complete wing must have had a length of at least 100 mm., and a width of 35–40 mm. The whole insect had in all probability a span of wing measuring 25·5 cm. (10 in. or more).

The outer third of the wing is differentiated from the rest by its uniform and gentle convexity, and by the character of the costa, subcosta, radius, and median veins, which pass outwards towards the wing-apex in straight lines, and show no trace of divisions until well beyond the middle of the wing, contrasting strongly

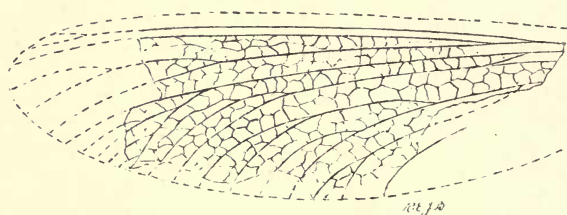


FIG. 1.—*Orthocosta splendens*, Bolton; restoration of wing, showing portion preserved and the character of the interstitial venation, natural size.—Middle Coal Measures (below the Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire. Moysey Collection, Mus. Pract. Geol. (nos. 30,222 and 30,223).

with the areas occupied by the marginal divisions of the median, cubital and anal veins. The inner two-thirds of the wing is marked by deep furrows, in which lie the marginal branches of the median vein, and the whole of the cubital and anal veins. The areas between any two veins in this region are markedly convex. The differences in character of the outer and inner portions of the wing are emphasised by a line of fracture which fairly accurately separates the two. Its occurrence suggests that it has followed a natural line of weakness, the more delicate inner part of the wing breaking away from the outer stronger portion.

The costa, subcosta, radius and median are all well-developed veins, stout in structure and standing out in relief. The first three retain this evidence of strength over two-thirds of their length, the median vein showing signs of attenuation beyond the proximal third.

The general structure of the wing indicates considerable powers of flight. The outer margin, of which only a portion is preserved, appears as a stout, slightly elevated and well-rounded ridge.

The subcosta agrees in general character with the costal remnant, and is

straight to the wing-tip, parallel with the outer margin, and not far removed from it. Basally it appears to be united to the radius.

The radius gives off the radial sector at about 10 mm. from its base, and then passes out to the wing-tip, at no point being more than 10 mm. from the subcosta. The radial sector diverges widely from the radius, the two enclosing a long, narrow triangular area. At 50 mm. beyond its origin it divides into two equal branches, which diverge to a distance of 3 mm. and then become parallel. The direction of the branches of the radial sector is such that they must have ended on the inner half of the wing-apex, the outer branch probably forking again before the wing-apex was reached. The median vein consists of two branches, the common origin of which is not shown, owing to the absence of the base of the wing. To the middle of the wing the two branches are parallel, and both pass beyond this point before branching. The outer branch attains a length of 66 mm. before branching, and then gives off four branches on its outer side, the last arising close to the margin.

The second of the four branches bifurcates. The inner branch of the median gives off one forward branch only, which forks into a feeble twig dying out in the polygonal meshwork, and into a stronger division which reaches the margin. The two branches of the median are united at the base of the wing by an oblique commissural vein which comes off at an acute angle from the outer branch, and passes obliquely to the inner branch.

The basal portion of the cubitus has been lost, so that its branching is not readily determinable. The main vein seems to have divided near the base into two equal branches, which curve down to the inner wing-margin, bifurcating twice in each case before the margin is reached. The eight marginal twigs of the cubitus thus produced enclose the middle third of the inner margin. The anal area is wholly destroyed on the wing, and only a trace of one vein can be distinguished on the counterpart. This is a narrow deeply-sunk vein which gives off feeble off-shoots on both sides. It diminishes in strength, so that the last portion of its course can only be determined with difficulty. The anal area is comparatively narrow and small, and exhibits few veins.

Family PTERONIDIIDÆ, Bolton (emend. Cockerell).

1912. Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 314.

Wings long and narrow. Outer margin arcuate. Median and cubitus with divergent branches.

The attempt to classify these wings is difficult. That they possess affinities with the genus *Polycereagra* is certain, but they are more simple and more Dictyoneurid in type. As Dr. Handlirsch observes, it is not possible to refer them to the family Polycereagridæ, and they must be taken as the type of a new family.

Prof. T. D. A. Cockerell has pointed out to me that the family name was originally wrongly written "*Pteronidiæ*," and that the generic name was ante-dated by *Pteronidea*, Rohwer, 1911. He thinks that the difference is sufficient to justify retention, although it is only a single letter ('Proc. U.S. Nat. Mus.,' vol. xlix, p. 469, 1915). Handlirsch ('Revision Paläozoischen Insekten,' 1919, p. 15) has made the same correction, but seems unaware that Cockerell forestalled him.

Genus **PTERONIDIA**, Bolton.

1912. *Pteronidia*, Bolton, Quart. Journ. Geol. Soc., vol. lxxviii, p. 313.

Generic Characters.—Wings three times as long as wide. Radial sector with five simple, backwardly directed twigs. Median dividing low down into two principal branches, and ending on the inner margin in five twigs. Cubitus stout, divided into two principal branches, the foremost with two twigs, and the hinder ending in four. Interstitial neuration of thin oblique nervures.

Pteronidia plicatula, Bolton. Plate I, fig. 3; Text-figure 2.

1912. *Pteronidia plicatula*, Bolton, Quart. Journ. Geol. Soc., vol. lxxviii, p. 313, pl. xxxii, figs. 1—3.

Type.—Incomplete wing and impression; Moysey Collection, Museum of Practical Geology, Jermyn Street (nos. 30,224 and 30,225).

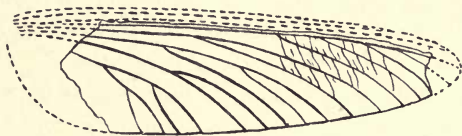


FIG. 2.—*Pteronidia plicatula*, Bolton; restoration of left wing, natural size.—Middle Coal Measures (below Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire. Moysey Collection, Mus. Pract. Geol. (nos. 30,224 and 30,225).

Horizon and Locality.—Middle Coal Measures (below the Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire.

Specific Characters.—Wings triangular in outline, with subacute tip, strongly plicated. Radial sector dividing into five simple twigs. Median with two principal branches and five marginal twigs. Cubitus wide-spaced; two principal branches, the inner doubly forked.

Description.—This is a long delicate wing, of which the outer marginal portion and the base are missing. It was probably about 70—75 mm. long, with a basal width of 20 mm., reduced to 8 mm. near the tip.

The outer margin must have been flatly convex, while the inner margin is

nearly straight. The tip of the wing is acute. The costal and subcostal veins are not seen. The radius is represented by a single forked vein, not shown in the figures. The radial sector is unbranched until well beyond the middle of the wing, beyond which it gives off four (possibly five) backward branches, which occupy the greater part of the tip of the wing and a portion of the distal inner margin.

The median is represented by two branches, the outer dividing into two twigs and the inner into three.

The marginal area occupied by the median is a little longer than that of the radial sector, and the two extend over the distal half of the inner wing-margin.

The cubitus is a relatively short and stout vein, dividing into two main branches, the foremost having two twigs, and the hinder dividing into four by a double bifurcation. Owing to the wide divergence of its branches the cubital area is larger than that of the median. The anal area was large, but the whole surface has been pitted by attempts to clear the matrix, and as a result the presence and character of the veins cannot be distinguished with certainty. It is possible that certain surface-indications are evidence of two simple widely separated veins. The wing-surface exhibits a strong plication.

Viewed obliquely, the wing shows a series of ridges formed by the vein with V-shaped intervening sulci, which only flatten out close to the wing-margin. Springing from the principal veins is a close series of fine cross-nervures, obliquely disposed in the direction of the wing-margin. The portion of the wing preserved is sufficient to indicate that as a whole it was triangular in outline.

Family HYPERMEGETHIDÆ, Handlirsch.

1906. Handlirsch, Proc. U.S. National Museum, vol. xxix, p. 672.

Costa marginal, costal area broad; radius simple, radial sector present; the median probably dividing at the base into two or more main branches, the first of which may become united to the radius. Cubitus forked near the base, with its branches widely spaced. Anal veins few, and anal area not exceeding one-third of the inner margin.

Handlirsch established this family for the inclusion of a gigantic wing of which only the basal half is known. The total length of the whole wing was estimated to be 120 mm., the basal half having a length of 60 mm. The discovery in the Coal Measures of Durham of a nearly similar wing adds to our knowledge of the group, and enables the family to be defined with more accuracy than was at first possible.

The general assemblage of characters found in the Hypermegethidæ is, I believe, highly suggestive of the Protodonata, but no definite conclusions can be formulated until the whole wing is known.

Genus **HYPERMEGETHES**, Handlirsch.

1906. *Hypermegethes*, Handlirsch, Proc. U.S. National Museum, vol. xxix, p. 672.

Generic Characters.—Costal border feebly convex, subcosta and radius close together along the greater part of their length. Cubitus composed of two, possibly more, parallel and simply forked branches, divided near the point of origin. Anal veins few; interstitial neuration of fine, irregularly anastomosing nervures.

Hypermegethes northumbriæ, Bolton. Plate I, fig. 4; Text-figure 3.

1917. *Hypermegethes northumbriæ*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 55, pl. iv, figs. 2 and 3, and woodcut in text.

Type.—Portion of the basal half of a left wing, in counterpart; British Museum (no. In. 18524).

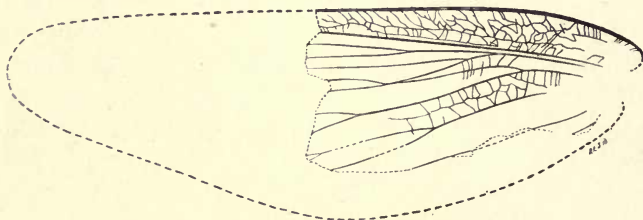


FIG. 3.—*Hypermegethes northumbriæ*, Bolton; suggested outline of left wing, restored, showing portion preserved, slightly less than natural size.—Coal Measures (shale above the Crow Coal); Phoenix Brickworks, Crawcrook, Durham. Brit. Mus. (no. In. 18524).

Horizon and Locality.—Coal Measures (shale above the Crow Coal); Phoenix Brickworks, Crawcrook, Durham.

Specific Characters.—Costal area wide, and crossed by an irregular meshwork of small veins. Median united with the radial sector basally, and giving off an inner branch which unites with the cubitus. Cubitus with a short stem forking into two equal and widely separated branches. Anal veins simple, and widely spaced.

Description.—The fragment is little more than a third of the whole wing, and its characters can only be determined with difficulty. The two halves of the nodule do not coincide, and the outline drawing of the wing is built up from details supplied by both halves. The inner margin, anal area and base of the wing have been lost, so that a little less than two-thirds of the outer portion of the basal half of the wing is present.

The portion of wing remaining being 63 mm. long, with a depth of 31 mm. at its widest part, the whole wing must have had a length of about 126 mm., or

5 in., and the whole insect a span of wing of nearly 11 in. The wing-fragment shows the basal portions of the costa, subcosta, radius, radial sector, median, and cubitus, and possibly a trace of an anal vein.

Much of the finer detail of the wing is not seen until the fossil is immersed in water—a mode of treatment suggested to me by Dr. F. A. Bather, F.R.S., who had previously photographed the wing in this manner, and brought out details of which, by ordinary methods, I could not find a trace.

The costa is moderately convex from its base to a distance of about 30 mm., beyond which it becomes straight. Separated from the outer or costal border by a wide area basally is the subcosta, an extremely feeble and hardly distinguishable vein. It passes straight to the outer margin some distance beyond the middle of the wing. The radius arises close to the subcosta, and is parallel with it. It gives off two branches posteriorly, the proximal branch passing obliquely towards the inner side of the wing-apex, while the second or distal branch arises from the radius a little further out, and keeps parallel with it.

I had formerly considered the proximal branch of the radius to be the radial sector, and the distal a branch of the radius; but as the interstitial neuration now shows the specimen to be closely related to *Hypermegethes schucherti*, the proximal branching vein must be regarded as the main stem of the median which has entered into union with the radius, and the distal branch as the radial sector.

Regarding the proximal offshoot of the radius as the median vein, it diverges widely from the radius, giving off a forward twig parallel with the radial sector, and then continues inwards and unites with the next vein, separating again a little further out on the inner side. A comparison of this assumed median vein with that of *H. schucherti*, Handl., is instructive. In the latter species the branching of the main stem of the median arises nearer the base of the wing than does the branching off of the radial sector. It is therefore somewhat in the position of the starting-point of the median vein as a free structure in the present wing. The median vein of *H. schucherti*, Handl., has, however, no union with the radius, the main stem running out towards the wing-apex parallel with the inner branch of the radius, giving off a backward branch of the cubitus, which passes obliquely inwards and unites with the anterior branch. In the middle of its length it gives origin to a twig running parallel with the main stem, and midway between that vein and the cubitus. The course of the median vein in the specimen here described is exactly similar to that of the branch of the median vein in *H. schucherti*, Handl., except that the inner branch not only unites with the cubitus, but crosses it.

The condition may be summarised by saying that, in *H. schucherti*, Handl., the median vein is entirely free and gives off an inner branch dividing into two twigs, of which the inner unites with the cubitus. In the specimen here described the median is united with the radius for some little distance, becoming free before the

radial sector is reached, and then forking, the inner twig uniting with and crossing the cubitus.

The cubitus has a short, stout basal stem, forking into two equal and somewhat widely separated branches, the outer uniting with the inner branch of the median. The inner branch is forked just before the broken edge of the wing is reached. Nearer the inner margin of the wing are traces of two other veins. The first has its basal portion missing, and follows a course parallel with the inner branch of the cubitus. It is strongly forked. The remaining vein is represented by three detached fragments. If Handlirsch's interpretation of the wing of *H. schucherti* is followed, we should regard both these veins as anal. I am, however, of opinion that, while the innermost fragmentary vein may be anal, the forked vein by its position, its forked character and stoutness, must be regarded as a portion of the cubitus. I am likewise of opinion that the first, and possibly the second, of the veins marked as anal in Handlirsch's figure of *H. schucherti*, ought also to be classed as cubital. Both in *H. schucherti*, and in this specimen, the anal area would have an enormous development and occupy most of the wing-margin, if the veins alluded to were wholly anal in character. I feel sure that, if the vein nearest the cubital had been better preserved, it would be found branching off from the cubitus.

The interstitial neuration is typically that of *Hypermegethes*. The intercostal area is filled with an irregular meshwork of fine nervures, with a tendency on the outer and inner sides to a transverse arrangement. Between the median and the cubital veins the interstitial neuration consists of short, straight and transverse nervures, and feeble traces of similar nervures can be seen in the median area. The cubital area is filled with a meshed neuration, larger and more regular than that of the intercostal area, and this seems to continue into the anal area.

Family CRYPTOVENIDÆ, Bolton.

1912. Bolton, Quart. Journ. Geol. Soc., vol. lxxviii, p. 315.

Wings short and broad. Apex rounded, costal vein marginal; subcosta feeble, and extending to near apex. Radius simple; radial sector and median with few divisions; cubitus with two main branches.

Among the insect-remains discovered by the late Dr. L. Moysey at the Shipley Manor Claypit is a small wing, 16 mm. long, unlike any previously known. It is typically Palæodictyopterous, and agrees remarkably well with Dr. Handlirsch's type-figure ('Mitth. Geol. Gesell. Wien,' vol. iii, 1910, p. 505, fig. 1). It differs from that form in the greater division of the cubitus, which ends in five twigs instead of three. The greatest depth of the wing was also, in all probability, nearer the base than in his figure. With the genus *Athymodictya*, Handlirsch ('Amer. Journ. Sci.'

[4], vol. xxxi, 1911, p. 298), the relationship is even closer, as in that genus the costa and subcosta are close together, the radial sector arises low down and is divergent from the radius, the median is a simple vein ending in three branches, while the cubitus is almost identical in its divisions, the difference being that the first forking arises at a higher point than that in *Athymodictya parva*, Handl., and that the inner simple ramus of the outer branch comes off a little below the middle of the wing. The anal veins number four in *A. parva* as against five in the wing under consideration. The wings are almost equal in size. It is not possible, however, to refer this wing to *Athymodictya* owing to the character of the interstitial neuration. In *Athymodictya* this is reticulated, while in the British wing the interstitial neuration is apparently made up of transverse nervures. If this point can be clearly determined, the wing may have affinities with the Homiopteridæ or with the Lithomantidæ, but it cannot be referred to either of these families. Neither Dr. Handlirsch nor I could satisfactorily refer the wing to any known family, and I therefore founded the family Cryptoveniidae to receive it.

Genus **CRYPTOVENIA**, Bolton.

1912. *Cryptovenia*, Bolton, Quart. Journ. Geol. Soc., vol. lxxviii, p. 315.

Generic Characters.—Wings twice as long as wide. Median, cubitus and anal veins curving sharply inwards. Interstitial neuration of straight cross-nervures.

Cryptovenia moyseyi, Bolton. Plate II, fig. 1; Text-figure 4.

1912. *Cryptovenia moyseyi*, Bolton, *loc. cit.*, p. 315, pl. xxxii, figs. 4—6.

Type.—Incomplete wing, in counterpart; Moysey Collection, Museum of Practical Geology, Jermyn Street (nos. 30,226 and 30,227).

Horizon and Locality.—Middle Coal Measures (below the top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire.

Specific Characters.—Costa feebly curved distally, subcosta reaching outer margin near wing-apex. Radius close to and parallel with the subcosta; radial sector arising from radius in basal half of the wing, the five branches occupying the inner half of the wing-tip. Median with the first branch undivided, and the second forking twice. Cubital vein strongly arcuate, two-branched, and ending in five twigs. Anal veins five or more in number, and curving sharply inwards. Wing plicated, and the interstitial neuration obscured by a mass of wrinkles.

Description.—A small delicate wing, incomplete at the base, which must have been very narrow and with the main veins crowded together. The total length of wing preserved is 16 mm., and its maximum diameter, in the cubito-anal region, is 8 mm.

The costal vein is stout and raised above the general level of the wing in the outer third of its length, where it curves backwards into the wing-tip. The subcostal is a weaker vein, parallel with and very close to the costa, dying out or joining the outer margin at the apex. The radius is a powerful undivided vein, parallel with the subcosta and reaching the middle of the wing-apex. The radial sector is given off about the middle of the length of the wing and forks into two equal branches, which again fork before reaching the margin; the outermost branch of the second forks again and divides just before the wing-apex is reached. The



FIG. 4.—*Cryptovenia moyseyi*, Bolton; restoration of left wing reconstructed from the wing-fragment and counter-impression, enlarged two-and-a-half times.—Middle Coal Measures (below the Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire. Moysey Collection, Mus. Pract. Geol. (nos. 30,226 and 30,227.)

inner half of the wing-apex is occupied by the five branches of the radial sector. The median vein is a comparatively simple structure, forking low down below the middle of the wing into two nearly equal branches. The outer branch remains undivided, and gently curves to the inner margin. The inner branch divides twice, first at a point near the middle of the wing, and again before the margin is reached. The median vein therefore ends on the margin in four twigs, three members of which arise from the inner of the two main branches.

The cubital vein is strongly arcuate, dividing near the base into two branches, the outer forking twice and the inner once. The cubital vein therefore ends in five twigs.

Family MECYNOPTERIDÆ, Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 82.

Handlirsch established this family to receive a large wing from the Middle Upper Carboniferous of Belgium, and placed it between the families Hypermegethidæ and Lithomantidæ. The characters of the family are based on those of the type-species, *Mecynoptera splendida*, Handl.

Genus MECYNOPTERA, Handlirsch.

1904. *Mecynoptera*, Handlirsch, Mém. Mus. Roy. Hist. Nat. Belg., vol. iii, p. 7.

1906. *Mecynoptera*, Handlirsch, Die Fossilen Insekten, p. 82.

Generic Characters.—Wing three to four times as long as broad, veins of costal region specially compact, and thickened basally. Costa, subcosta and radius closely approximated and tuberculated. Radial sector and median well developed, and occupying a considerable portion of the wing-surface. Cubitus small. Interstitial neuration of transverse nervures in junction areas of principal veins, and with a meshwork further out.

Mecynoptera tuberculata, sp. nov. Plate II, fig. 2; Text-figures 5 and 6.

1911. *Stenodictya lobata*, Baldwin (*errore*), Geol. Mag. [5], vol. viii, p. 75.

Type.—Portions of two fore-wings, and the cubito-anal portion of a hind-wing contained in a nodule of ironstone, 3 in. long, and $1\frac{1}{2}$ in. wide; British Museum (no. In. 18,576).

Horizon and Locality.—Middle Coal Measures (grey-blue shales at 135–180 feet above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire.

Specific Characters.—Principal veins thickened at base and finely tuberculated. Costal margin almost straight, much thickened at base, and covered with a fine

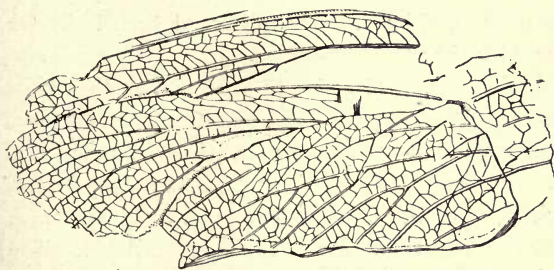


FIG. 5.

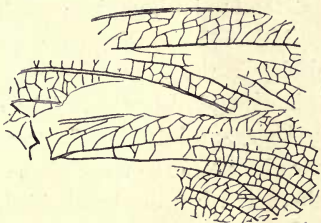


FIG. 6.

FIG. 5.—*Mecynoptera tuberculata*, sp. nov.; diagram of remains of the two fore-wings, and cubito-anal portion of a hind-wing (the sub-costa appearing as a fine line close to the radius, and sending off three branches to the costal margin), enlarged one-and-a-half times.—Middle Coal Measures (above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire. Brit. Mus. (no. In. 18,576).

FIG. 6.—*Mecynoptera tuberculata*, sp. nov.; diagram of fragmentary impression of the two fore-wings, enlarged one-and-a-half times.—Middle Coal Measures (above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire. Brit. Mus. (no. In. 18,576).

tuberculation. Subcosta sunken, close to costa, and extending to the wing-apex. Radius close to costa, tuberculated, and elevated. Radial sector arising low down, much branched. Median with two main branches, the first simple, the second with three twigs. Cubital vein small.

Description.—The type-specimen comprises remnants of the two fore-wings, 60 mm. long and 18 mm. wide, and a portion of the cubital-anal area of a single hind-wing in one ironstone nodule. A similar ironstone nodule from the same horizon and locality shows the radius and radial sector areas of the two wings of a second insect.

When complete, the wings must have had a length of 65—70 mm. They were originally identified with those of *Stenodictya lobata*, Brongniart, and are quoted as such in the faunal lists of the Sparth Bottoms deposits, but with no detailed description or figures.

When the specimens were first examined they presented an apparently anomalous union or suppression of certain of the principal veins. Careful development has since shown that what was formerly considered to be the outer or costal margin of the wings was really the thickened and tuberculated radius vein, and that the outer margin, with the costa and subcosta, had been hidden under the matrix. A little of the outer marginal costa and the subcosta are now uncovered, and the wing-structure is therefore proved to be of a normal type.

The three wings in the larger, more nearly complete specimen are superposed and fragmentary. The uppermost fore-wing is represented by two portions, one having a little of the outer or costal margin, the subcosta, and the greater part of the radius and radial sector. The second part consists of the median, and a portion of the cubitus. The second fragment is displaced backwards, allowing the radius and radial sector of the second fore-wing to be seen. The median-cubital area of the hind-wing is very thin and closely pressed on the rest, but the course of the veins is clearly discernible, and by their sharp inward turn indicates that the hind-wings were much broader than the fore-wings.

Although the wings are thus broken up, displaced, and superposed, the parts missing in the one wing are present in the other, and it is possible to reconstruct their general character. The outer margin is almost straight, gently rounded into the base, and into the wing-apex. The subcosta is weak, and lies in a deep sulcus, extending into the apex of the wing. The radius is a little elevated, thickened, tuberculated in the basal third, and in close proximity to the subcostal vein. The radius is a strong vein, raised above the level of the rest of the outer margin of the wing, so that when the latter was hidden, it naturally appeared to be the outer marginal costal vein. It is much thickened in its basal third, tuberculated, and remains parallel with the subcosta in the apex of the wing.

The wing-space taken up by these three veins is very small, and their close approximation and the coriaceous thickening of the costa and radius serve to give a considerable degree of strength and rigidity to the outer margin of the wing. The radial sector passes straight outwards to the apex of the wing, giving off three inner branches in one wing and two in the other, the first branch only forking. The first branch soon forks, the outer fork dividing into two twigs, and the inner into three upon the distal inner half of the wing-apex. The median is a large vein, occupying the greater part of the inner half of the wing. It divides at its point of origin into an outer undivided branch which traverses the middle of the wing, and an inner branch which is widely separated from its fellow, and gives off three twigs to the wing-margin, the first forking in the middle of its length. Cubital veins are repre-

sented by two undivided elements which are directed obliquely to the margin. The inner margin of the wing is more curved than the outer, and merges into the apex. The interstitial neuration is remarkable. Between the costa, subcosta and radius it consists of short stout nervures crossing the areas somewhat obliquely, and in some cases arranged in V-shape. The area between the radius and radial sector is crossed by a numerous S-shaped series of nervures, which are joined up into a meshwork in the outer or radial half of the area. The area itself is very wide, and only equalled by that separating the two branches of the median.

The radial sector and the median occupy the greater part of the wing-surface.

The remaining areas are crossed by transverse nervures near the junction of branches with the principal veins, and further out by nervures which are joined up by zig-zag longitudinal branches which occasionally enclose polygonal cells. The interstitial neuration is very well developed, and must have added materially to the strength of the wings.

Affinities.—The close approximation of the costa, subcosta and radius, and the coriaceous thickening and tuberculations of the principal veins, are characters which may rank as of generic importance. Less distinctive, but also characteristic, is the interstitial neuration of the transverse nervures and meshwork, with its minute monilation.

The characters of the genus *Mecynoptera* are in closest agreement with those of this insect. There is the same approximation of the costa, subcosta and radius, the radial sector is widely spaced from the latter, and the interstitial neuration consists of transverse nervures near the junctions of the principal veins and their branches, and of a meshwork further out. The general outline of the wing is also the same.

M. splendida, Handlirsch, throws light on one point which had proved a difficulty in the determination of the wings. It has the radial sector of large size and much branched, the divisions occupying all the inner half of the apex of the wing, and extending out on the inner margin into the area usually occupied by the outer branches of the median. Prior to noting this feature in *M. splendida*, I had formed the opinion that the first division of the radial sector was the median, which had united with the radial sector and the radius.

The broken condition of the Rochdale wings prevents absolute determination of this point, but by analogy I conclude that the whole vein which branches off from the radius basally is the radial sector, and the next vein the median. This conclusion also removes the insect from the neighbourhood of *Enigmatodes danielsi*, Handlirsch, a wing discovered in the Coal Measures of Mazon Creek, near Morris, Illinois, U.S.A., which possesses the same character of interstitial neuration, but with the divisions of the median vein stretching out to the wing-apex, and the costa, subcosta and radius more widely separated.

Unless it can be shown by the discovery of a whole wing that the reconstruction now attempted is faulty, the balance of evidence is in favour of the provisional reference of the Sparth Bottoms wing to the genus *Mecynoptera*.

Family INCERTÆ SEDIS.

Genus **PALÆOMANTIS**, Bolton.

1917. *Palæomantis*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 52.

Generic Characters.—Wings short, twice as long as broad. Apex well rounded. Radius, radial sector and median all powerful veins with few divisions. Median with two main branches. Anal veins directed almost straight inwards. Interstitial neuration forming an irregular meshwork.

Palæomantis macroptera, Bolton. Plate II, fig. 3; Text-figures 7 and 8.

1871. "Wing of large insect," Higgins, Pres. Add. Liverpool Naturalists' Field Club, vol. ii, p. 18.

1917. *Palæomantis macroptera*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 48, pl. iii, figs. 3—4, text-figs. 2—3.

Type.—Remains of two wings in nodule; Liverpool Museum.

Horizon and Locality.—Middle Coal Measures; Ravenhead railway cutting, near St. Helens, Lancashire.

Specific Characters.—Divisions of radial sector occupying almost the whole tip of the wing. Divisions of median and cubital veins occupying distal two-thirds of inner margin.

Description.—The larger half of the nodule has lost a portion which contained the tip of the right wing. The proximal third of the left wing remains, with its dorsal surface uppermost, and its ventral surface closely applied to that of the right wing. It is evident that the whole of the two wings was contained in the nodule, but, when the latter was split open, a thin film of ironstone carried away the middle and distal portions of the left wing.

One unusual feature in the position of the wings is that they lie with their ventral surfaces apposed. To bring them into this position one must have become bent under the body, instead of falling sideways across the thorax of the insect. The body of the insect would thus, if the wings still remained attached, lie between the two. No trace of the body can be seen, but the left wing has a deep inward flexure, such as it would naturally acquire if the body had been carried round with the right wing and pushed into the anal area of the left wing. Had the body been carried round in this way the right wing would not coincide in position with the left, but be thrust further out, which is actually the case, the outward displacement

of the right wing as compared with that of the left being at least 20 mm. The wings are remarkably wide—a feature which we usually associate with hind-wings.

The outer third of each wing is supported by strong and fairly rigid veins, becoming more slender as they pass towards the wing-tip. The inner margins of the wings are more membranous, and were evidently lacking in a rigidity equal to that of the outer margins.

A little more than the proximal third of the *left wing* is present and in good preservation. It is 42 mm. long and about the same in width. The impression on the other half of the nodule shows apparently all but the wing-apex. The main stems of the costa, subcosta, radius and median are all stout, and in relief on the wing-surface. The cubital and anal veins are but half the thickness of the former and lie in shallow grooves. The costal vein forms the outer margin of the wing, which is slightly convex forwards, and slopes gradually into the apex. The subcosta is

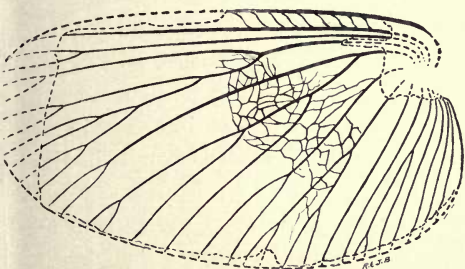


FIG. 7.

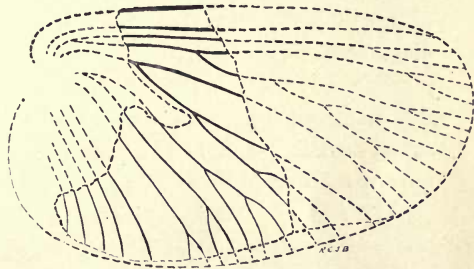


FIG. 8.

FIG. 7.—*Palæomantis macroptera*, Bolton; restoration of left wing, with restored outline, natural size. Middle Coal Measures; Ravenhead Railway Cutting, near St. Helens, Lancashire. Liverpool Museum.

FIG. 8.—*Palæomantis macroptera*, Bolton; restoration of right wing, natural size.—Middle Coal Measures; Ravenhead Railway Cutting, near St. Helens, Lancashire. Liverpool Museum.

separated from the outer margin by a costal area 4 mm. broad. It passes almost in a straight line to the outer edge of the wing-apex, and is joined to the costa by a series of oblique transverse branches nearly parallel with each other. The radius arises close to the base of the subcosta, and diverges a little from it in its course to the apex, forking once just before the broken edge of the wing is reached. The main stem of the radial sector probably arises from the radius close to the base of the latter, but the exact point cannot be determined, owing to the base of the wing being broken away. The radial sector forks three times, and each of the resultant twigs again divides on the wing-apex. The median vein, which is stout basally, divides very low down into two branches, the outer of which has a feeble forking near the inner margin, while the inner branch forks three times. The cubitus is a much weaker vein than its fellows, and divides near its point of origin into two branches. The first branch forks once and the second twice. Seven anal veins are present, all undivided except the third, which forks twice. The interstitial

neuration is in the form of a meshwork, except in the intercostal area, where are the transverse cross-nervures already noted.

Much less of the *right wing* remains than of its fellow, but sufficient is present to show that the neuration was not quite the same. The median ends in five divisions in place of six, and the cubitus has seven final branches instead of six. The greatest width of the wing is along a line drawn from the outer margin to the middle of the cubital area on the inner margin, the width being 40 mm. The absence of the apex in each wing is unfortunate, as it renders the outline of the whole wing a little uncertain. The shape of the nodule indicates that very little of the wings is missing, if they were wholly included in the nodule, as seems probable. The somewhat semicircular inner wing-margin and the short wide wings indicate a broadly rounded wing-apex.

Affinities.—The interstitial neuration is much like that of *Hypermegethes*. The great width of the wings is a character usually associated with the hind-wings of members of the family Lithomantidæ, although in this case the wings lack the distal attenuation noticed in the hind-wings of that family. With *Titanodictya jucunda*, Scudder, there is a close relationship, both in the general character of the main veins, the interstitial meshwork in all areas other than intercostal and subcosta-radial, and in the presence of the same oblique cross-nervures in the intercostal area in these wings.

The true systematic position of the genus seems to lie between the Lithomantidæ and the genus *Titanodictya*, and closest to the latter. Because of the greater development of a meshwork neuration between the main veins, and the limitation of cross-nervures to the intercostal area, I regard this genus as more primitive than any of the Lithomantidæ, but closely related thereto.

Family LITHOMANTIDÆ, Handlirsch.

1906. Handlirsch, Proc. U.S. National Mus., vol. xxix, p. 673; also Die Fossilen Insekten, p. 82.

This family is closely allied, by wing-structure, to the Dictyoneuridæ. The branching of the main veins has proceeded further than in the Dictyoneuridæ, and the body, where it has been preserved, shows striking differences. The family is represented in the Coal Measures of Great Britain and North America and in the Upper Carboniferous of continental Europe.

Genus LITHOMANTIS, Woodward.

1876. *Lithomantis*, H. Woodward, Quart. Journ. Geol. Soc., vol. xxxii, p. 60.

Generic Characters.—Large insects with two pairs of flying wings; the hinder pair double the width of the anterior pair. Prothorax produced into a central

rostral-like process, acutely pointed, and expanded into two lateral bulbous lobes. Thorax wide. The interstitial neuration consists usually of stout transverse nervures, occasionally forking or in a loose meshwork.

Lithomantis carbonarius, Woodward. Plate II, fig. 4; Text-figure 9.

1876. *Lithomantis carbonarius*, Woodward, *loc. cit.*, p. 60, pl. ix, fig. 1.

1893. *Lithomantis carbonarius*, Brongniart, Faune Entom. Terr. Prim., p. 489, fig.

1906. *Lithomantis carbonarius*, Woodward, Geol. Mag. [5], vol. iii, p. 25, fig. 3 (*non* fig. 1).

1906. *Lithomantis carbonarius*, Handlirsch, Die Fossilen Insekten, p. 83.

Type.—Portions of the fore- and hind-wings, with prothorax, and a left anterior leg in nodule; British Museum (no. I. 8118).

Horizon and Locality.—Coal Measures; Scotland.

Specific Characters.—Hind pair of wings double the width of the fore pair. Outer wing-margin straight, costa and subcosta close together; radius a weak vein, giving off the radial sector far out. Median small. Cubitus a powerful vein with numerous widely spaced branches. Anal veins six or more.

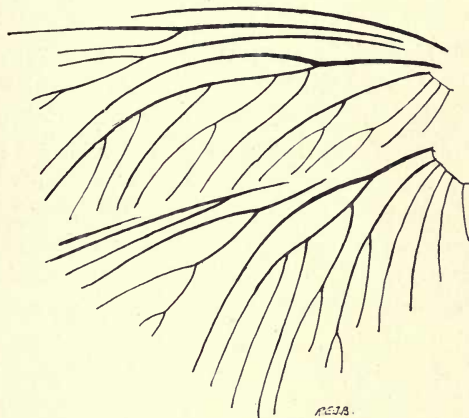


FIG. 9.—*Lithomantis carbonarius*, Woodward; diagram of neuration of the left fore- and hind-wings, natural size.—Coal Measures; Scotland. Brit. Mus. (no. I. 8118).

Description.—The type-specimen lies on the surface of one half of an ironstone nodule, the counterpart being lost. It was obtained by Mr. Edward Charlesworth from the Coal Measures of Scotland, but the locality and horizon are not known.

The remains consist of portions of two pairs of wings, those of the left side being most nearly complete. In no case is the apex of the wing or the inner margin preserved. Lying in front of the wings are a pair of very large convex lobes which Dr. Woodward regards as part of the prothorax, and in front of these is a roughly quadrangular structure prolonged forward in the middle line into a styliform process or rostrum. Woodward describes the latter as "the small head

with its eyes," but no definite trace of the latter are observable. The "head" is small, not more than 7 mm. wide, and between 5—6 mm. long at the sides; medially it is prolonged into the rostral process, which is about 8—9 mm. long and ending in a sharp point. I am unable to distinguish any dividing line between the "head" and the prothorax; on the other hand, the margin of the latter is continuous with and inseparable from it. The marking which Woodward has regarded as representing eyes is, I believe, the thickened margin. I am of opinion that the whole structure is wholly prothorax, and that the head lies concealed beneath. The main mass of the prothorax is 30 mm. wide, with a flattened margin, best seen on the left side. Within the flat margins rise two low dome-shaped lobes separated by a wide hollow in front, their margins meeting in an obtuse angle posteriorly. The median edge of each lobe dips sharply into a wide median hollow, and from each of these edges arises a series of veins, which spread out to the lateral margins of the lobes. The areas between the veins are occupied by a fine meshwork of smaller veins.

A trace of the mesothorax is shown between the bases of the fore-wings as a slight transverse bar, a small rounded tubercle lying in front and a little to the left of the middle line.

The left fore- and hind-wings are the most nearly perfect, the hind-wing being 56 mm. long, with a greatest width of 30 mm. The fore-wing is a little shorter and narrower. The outer margin appears to have been straight, and the costa and subcosta closely approximated. Traces of both veins are present. The radius is a straight thin vein not far removed from the subcosta along its whole length, and giving off the radial sector beyond the middle of the wing. The radial sector comes off at an acute angle, going out to the wing-apex and keeping closely parallel with the radius. The median is somewhat inconspicuous owing to the great length of the main stem, and the narrow areas which bound it between the radius and the prominent cubitus. It gives off two outer branches before reaching the broken edge of the wing. The median vein of the hind-wing has three outer branches, the first arising nearer the base than the point of origin of the radial sector, whereas in the fore-wing the first branch arises distally to the origin of the radial sector. The median of the hind-wing is a more important vein than its fellow in the fore-wing and occupies a greater area owing to its greater inward curvature. The cubitus is a powerful vein with widely spaced divisions, the first branch, both in fore- and hind-wings, coming off from the main stem on the outer side, and low down near the base of the wing, and then passing in a bold convex sweep down to the distal portion of the inner margin. On its inner side the cubitus gives off five branches, the fourth forking in the middle of its length. The branches arise at irregular distances, and the main stem reaches the margin far out towards the wing-apex. The cubitus of the hind-wing gives off a large outer branch which is almost equal in strength to the main stem. This arises

even nearer the base than its counterpart in the fore-wing, but its great length is masked by the development of the median. Beyond the origin of the outer branch the cubitus gives off three inward branches, the first forking. Owing to the strong inward curvature of the cubitus and its branches, the succeeding anal veins are directed almost straight inwards. The anal veins are six in number, the first forking twice, and ending on the margin in three branches.

The remaining veins are undivided. The cubital and anal veins of the fore-wing are more obliquely disposed than those of the hind-wing, and the latter has an anal area much larger than that of the fore-wing.

The interstitial neuration consists of short stout cross-nervures, which occasionally fork, and in the wider areas unite to form a meshwork.

A triangular area is marked off from the base of each wing by a deep furrow. This Woodward correlates with a similar area in the wing of *Gryllacris* (*Corydalis*) *brongiarti*, which Swinton ('Geol. Mag., [2], vol. i, 1874, p. 337, pl. xiv, fig. 3) has described as a stridulating organ. As stated elsewhere, I am of opinion that Swinton's conclusions in the case of *G. brongiarti* were founded on a misinterpretation of the wing, and that no stridulating organ, or similar structure, is present. In the case of *L. carbonarius* such a structure would apparently be useless, as none of the wings could come into such close apposition as would allow the structure to be used. I am unable to determine its purpose or significance, unless it be a portion of the musculature attachment of the wing.

Traces of a fore-leg are present, projecting from beneath the left lobe of the prothorax. Its structure is too indefinite for description.

The wings were probably one-fourth or one-third longer than the portion preserved—an estimate which would make each complete wing about 70 mm. long, with a spread of about 140 mm., or 6 inches.

Genus **LITHOSIALIS**, Scudder.

1881. *Lithosialis*, Scudder, Geol. Mag. [2], vol. viii, p. 299.

Generic Characters.—Wings three to four times as long as wide. Outer and inner margins almost parallel; intercostal area wide basally, and diminishing to extinction at apex of wing. Radius simple; median with two main branches, and cubitus large; anal veins few and oblique.

The wing on which this genus is founded is interesting as being the first discovered in British Palæozoic rocks, except the problematic examples mentioned by Lhuyd and not otherwise known. Supposed to be a plant, the wing was first sent by Mantell to Brongiart, who in turn referred it to Audouin. The latter recognised its insect character, and brought it before the Entomological Society of France, the Academy of Sciences, and the Assembly of German

Naturalists at Bonn. Audouin described the wing as that of an unknown Neuropterous insect allied to *Hemerobius*, *Sembris* and especially to *Corydalis*. Mantell (? Audouin) described it as closely resembling a species of living *Corydalis* of Carolina. Swinton states that Mantell purchased the fossil at a sale of Parkinson's collection, although Mantell ('Medals of Creation,' p. 554) says that he "discovered" it in a nodule from Coalbrookdale. Possibly the nodule had previously formed part of the Parkinson Collection. Both the figures by Mantell and Murchison are badly drawn, and it was not until 1874 that a reliable drawing was published by Swinton. The latter author devoted considerable attention to a "serrated vein" at the base of the wing, which he regarded as a stridulating organ. He therefore referred the wing to the Orthoptera, and to the genus *Gryllacris*. Scudder threw considerable doubt on Swinton's conclusions, and showed that such an organ so placed could not have been of any service. As we shall see later, the supposed stridulating organ is merely a torn edge of the base of the wing. A study of the wing-structure convinced Scudder that the wing was most closely related to the *Lithomantis carbonarius*, Woodward. Being generically distinct from *Lithomantis*, and from living types, he gave the insect the generic name of *Lithosialis*.

Lithosialis brongniarti (Mantell). Plate III, fig. 1; Text-figure 10.

- 1833. *Corydalis* ?, Audouin, Ann. Soc. Ent. France, vol. ii, Bull., p. 7.
- 1836. *Corydalis* ?, Audouin, Bridgewater Treatise, vol. ii, p. 77.
- 1844. *Corydalis brongniarti*, Mantell, Medals of Creation, ed. 1, vol. ii, p. 578, lign. 124, fig. 2.
- 1854. "Sialidæ," Pictet, Traité de Paléontologie, ed. 2, p. 377, pl. xl, fig. 1.
- 1867. *Corydalis*, "allied to," Murchison, Siluria, ed. 4, p. 300, woodcut 80.
- 1871. *Corydalis brongniarti*, Woodward, Geol. Mag., vol. viii, p. 387 (name only).
- 1874. *Corydalis brongniarti*, Swinton, Geol. Mag. [2], vol. i, p. 339, pl. xiv, fig. 3.
- 1875. *Gryllacris (Corydalis) brongniarti*, Woodward, Geol. Mag. [2], vol. ii, p. 622.
- 1876. *Corydalis brongniarti*, Woodward, Quart. Journ. Geol. Soc., vol. xxxii, p. 62.
- 1880. *Corydalis brongniarti*, Nowak, Jahrb. k.k. Geol. Reichsanst., Wien, vol. xxx, p. 73, pl. ii, fig. 4.
- 1881. *Lithosialis brongniarti*, Scudder, Geol. Mag. [2], vol. viii, p. 299.
- 1883. *Lithosialis brongniarti*, Scudder, Mem. Bost. Soc. Nat. Hist., vol. iii, p. 220, pl. xvii, figs. 1, 2, 8, 9.
- 1885. *Protogryllacris brongniarti*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 59.
- 1893. *Lithomantis brongniarti*, Brongniart, Faune Entom. Terr. Prim., p. 371, figs. 17, 18.
- 1906. *Lithosialis brongniarti*, Handlirsch, Die Fossilen Insekten, p. 84, pl. x, fig. 13.

Type.—A left fore-wing; British Museum (Mantell Coll., *olim* Parkinson Coll., no. 11,619).

Horizon and Locality.—Coal Measures; near Coalbrookdale, Shropshire.

Specific Characters.—Radial sector with not more than three branches; median much branched, and occupying much of the distal inner wing-margin. Cubitus with three divisions. Anal veins few, and very oblique.

Description.—The left fore-wing measures 61 mm. long and 18 mm. wide across the distal third. The apex, the inner margin and a very small portion of the base are missing. The wing appears to have been strap-shaped, with a blunt apex, the inner margin curving most into the apex.

The outer margin is feeble, almost straight over the greater part of its length, and slightly sloped backwards. Basally it dips abruptly inwards to the point of attachment. The subcosta is widely spaced from the outer or costal margin proximally, the two gradually approaching each other until they meet at the wing-apex. The radius passes straight out to the apex, giving off the radial sector before the middle of the wing is reached; the radial sector remains undivided up to the distal third of the wing, beyond which it forks twice. The median vein divides a little further out than the radial sector, forming two strongly divergent branches, an outer large branch with two large forward twigs, and a small inner branch which forks, the inner twig forking again. The median, therefore, ends on the inner margin of the wing in six twigs.



FIG. 10.—*Lithosialis brongniarti* (Mantell); diagram of neuration of left fore-wing, natural size.—Coal Measures; near Coalbrookdale, Shropshire. Mantell Collection, *olim* Parkinson Collection, Brit. Mus. (no. 11,619).

The cubitus divides into three branches, the first arising low down, and passing in a bold sweep beyond the middle of the inner margin. The anal veins are five in number, all but the first being undivided. The first anal forks near the base, the outer branch forking again.

The whole wing is covered by a numerous series of strong transverse nervures, rarely branching, and usually crossing at right-angles to the main veins. A few are oblique or curved.

The “file” or “serrated vein,” described at length by Swinton, and by him correlated with that present in recent forms of *Gryllacris*, appears to be nothing more than an irregular torn edge of the basal part of the wing, which is also lifted up a little above the general level. The torn edge extends along the line of the median vein for a short distance, and wholly lacks the symmetry and detail given to it by Swinton.

Affinities.—Although closely allied to *Lithomantis carbonarius*, Woodw., this wing differs in the great width basally of the intercostal area, and in the straighter course of the cubitus and anal veins, due to the greater length of the wing. The interstitial neuration is much the same.

Genus **PRUVOSTIA**, novum.

Generic Characters.—Fore-wings two and a half times as long as wide; outer and inner wing-margins almost parallel; wing-apex well rounded. Subcosta widely removed from the costal margin basally, and apparently not connected with the costa or radius. Radius straight with divergent radial sector. Radial sector, median and cubitus all distally branched. Anal veins few. Interstitial neuration of straight cross-nervures.

Certain features of this wing are suggestive of the Protorthoptera. These are the wide basal, intercostal area, the basal origin of the radial sector, and the remote branching of the radial sector, median and cubital veins.

It is, however, more nearly allied to *Lithosialis* than to *Metryia analis*, Handl., for example, among the Protorthopteroids. The great length before division of the main stems of the radial sector, median and cubitus, their strong divergence, and the many branches of the median, form an assemblage of characters not elsewhere known, and certainly deserving of generic recognition.

It is with pleasure that I attach to this genus the name of Dr. P. Pruvost, of Lille University, in recognition of his valuable work on the fossil insects of the north of France.

Pruvostia spectabilis, sp. nov. Plate III, fig. 2; Text-figure 11.

Type.—A left fore-wing; British Museum (Johnson Collection, no. I. 15,894).

Horizon and Locality.—Middle Coal Measures (clay ironstone nodules in the Binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffordshire.



FIG. 11.—*Pruvostia spectabilis*, sp. nov.; diagram of neuration of left fore-wing, natural size.—Coal Measures (clay ironstone nodules in the binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 15,894).

Specific Characters.—Outer margin convex at base, and inclining inwards to the apex. Subcosta straight, not reaching the apex of wing. Radius straight, giving off radial sector near base; radial sector twice branched, median divergent, three times branched, the first two branches forking. Cubitus dividing basally into two, the outer forking three times, the inner branch once.

Description.—A left fore-wing 52 mm. long and 24 mm. wide, almost covering the surface of one half of the median plane of a reddish-brown ironstone nodule. A little of the base of the wing is missing, while a part of the wing-apex is concealed

by a film of ironstone which cannot be removed. Fortunately the slight film of ironstone does not hide the outline of the wing, and it is evident that the outer and inner wing-margins are almost parallel, while the apex is well rounded. The outer margin merges by a well-rounded contour into the wing-apex. The subcosta is well-marked, widely removed from the outer border proximally, and lies in a shallow groove formed of the intercostal and radial subcostal areas. These two areas are reduced distally to less than half their proximal diameter owing to the backward inclination of the outer margin. The subcosta seems to die out near the radius, about 7 mm. from the wing-apex, and gives off a numerous series of irregularly spaced and forwardly directed nervures, which are at first straight and then curved towards the wing-apex. At their point of origin the cross-nervures are very distinct, but they thin, and occasionally die out, before reaching the outer margin. The radius is a strong vein, passing perfectly straight out from the wing-base to the outer part of the wing-apex. The radial sector arises near the base of the radius, gradually diverging from it up to the junction of the middle and outer thirds, where a single branch is given off, the latter taking a position parallel with the main stem of the radial sector, and entering the middle of the wing-apex. Eleven mm. further out and within 7 mm. of the apex a second branch is given off, which lies evenly between the main stem and the first branch. The median vein arises so close to the radius as to appear united with it. Like the radial sector, it does not divide until it reaches the junction of the middle and outer thirds of the wing. Here the first inward branch arises, and at equal distances further out are given off two more; the first two each fork in the middle of their length, the third remaining undivided; the median ends therefore on the inner wing-margin in six divisions. The cubitus consists of two, and possibly three, main stems. Owing to the base of the wing being broken away these stems are not seen to be in actual union. Little doubt can exist as to the union of the first two, but if the third vein is a branch of the cubitus, it can only join the other two by a strong outward curvature. This third vein may be the first anal, although its manner of division is similar to that of the cubitus, in this respect agreeing with what is seen in the first anal of *Lithosialis brongiarti*. The next vein is parallel with the one succeeding, which is undoubtedly anal, while it shows an increasing basal divergence from the second cubital. For this reason I have regarded the third vein as the first anal. The first branch of the cubitus diverges widely from the median, passing obliquely to the inner margin of the wing, which is reached just beyond the middle third. Owing to the great divergence of the first cubital branch from the median, the area between the two, at the point where they first branch, is very wide—almost twice the width of any other area.

The first cubital vein gives off three outward twigs. The second is parallel to the first as far as its division into two equal twigs. The next vein is that to which I have already alluded as a possible third branch. It is widely separated

from the undoubted cubitus, and by reason of its two forward branches resembles the cubital elements in front of it. Its wide separation from the second branch of the cubitus supports the view that it is the first anal vein. The undoubted anal veins are two in number, undivided, and passing backwards very obliquely to the wing-margin. More anal veins may have been present, but it is very doubtful. The wing-surface is much wrinkled across both the length and breadth, and traversed by numerous cross-nervures, which are most evident in the median area.

Affinities.—The wing is typically Palæodictyopteroid, and in the development of the radius, radial sector, and cubitus, shows an affinity to *Lithosialis bronquiarti*. It differs markedly from that species, however, in the great length of the main stems before divisions arise.

Dr. Tillyard, to whom I have shown my enlarged drawings, is of opinion that *Pruvostia* is allied to *Pseudofouquea* rather than to the *Lithomantidæ*.

Family BREYERIDÆ, Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 95.

Wings markedly triangular, with broadened bases. Costa, subcosta and radius brought closely together in the outer part of the wing, the median with few divisions. Cubitus and anal veins directed almost straight inwards, at right angles to the length of the wing.

Genus BREYERIA, Borre.

1875. *Breyeria*, Borre, Ann. Soc. Entom. Belg., vol. xviii, p. 40.

1908. *Stobbsia*, Handlirsch, Die Fossilen Insekten, p. 1348.

Generic Characters.—Wings two and a half times as long as wide. Outer wing-margin straight; apex curved inwards. Inner wing-margin strongly convex. Costa marginal, subcosta parallel and joining the radius near the wing-apex. Radius giving off the radial sector near the base of the wing, and reaching the apex undivided. Radial sector subparallel to radius. Median boldly curved inwards almost at a right angle. Cubitus less curved than the median. Anal veins few. Interstitial neuration of two kinds, that of the intercostal and radial sector areas of short straight nervures, and that of the remaining areas of irregular thin nervures which tend to anastomose into a loose meshwork or reticulate arrangement.

Breyeria woodwardiana (Handlirsch). Text-figures 12, 13.

1903. "Allied to *Lithomantis carbonarius*," Stobbs, Geol. Mag. [4], vol. x, p. 524.

1906. Palæodictyopteron, sp., Handlirsch, Die Fossilen Insekten, p. 126.

1906. *Lithomantis carbonarius* (?), Woodward, Geol. Mag. [5], vol. iii, p. 26, fig. 1.

1908. *Stobbsia woodwardiana*, Handlirsch, Die Fossilen Insekten, p. 1348, text-fig.

Type.—Greater part of a left hind-wing; Mr. J. T. Stobbs' Collection.

Horizon and Locality.—Peacock marls overlying the Peacock Coal, and near the top of the workable Coal Measures; Foley, near Longton, Staffordshire.

Specific Characters.—Radial sector dividing in its distal half into fine inwardly directed twigs which end on the distal third of inner margin. Median and cubitus with few widely spaced branches, occupying greater part of inner margin. Anal veins about three to four in number.

Description.—The specimen has not been available for examination, and my observations are based on the figures published by Woodward and Handlirsch. It is probable that neither of these figures is wholly correct, Handlirsch pointing out what appears to be an obvious error by Woodward in the character of the cubitus

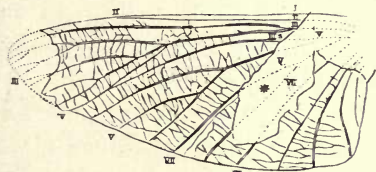


FIG. 12.

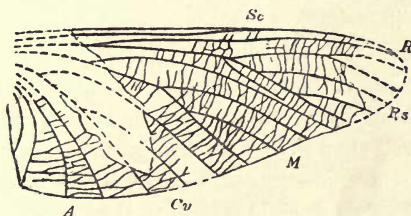


FIG. 13.

FIG. 12.—*Breyeria woodwardiana* (Handlirsch); left hind-wing as restored and figured by Dr. H. Woodward under the name of *Lithomantis carbonarius*?, natural size.—Coal Measures (Peacock marls overlying the Peacock Coal); Foley, near Longton, Staffordshire. Mr. J. T. Stobbs' Collection.

FIG. 13.—*Breyeria woodwardiana* (Handlirsch); same left hind-wing as restored and figured by Dr. A. Handlirsch under the name of *Stobbsia woodwardiana*, nearly natural size. A = IX, anal; Cu = VII, cubitus; M = V, median; R = III, radius; Rs = IV, radial sector; Sc = II, subcosta; I, costa.

vein, and the position and mode of division of the radial sector being doubtful. Notwithstanding this difficulty, I have by means of an old plaster cast been able to satisfy myself upon the more essential details.

The fragment is 50 mm. long and 20 mm. wide, and consists of the greater part of a left wing, of which the base and a portion of the basal third are stated to be obscured by a pinnule of *Neuropteris*. The maximum width is across the anal area, beyond which the wing rapidly narrows owing to the forward direction of its inner margin. The costal vein is marginal and strong, passing in an almost straight line distally until joined by the subcosta, after which it curves gradually backwards into the wing-apex. The subcosta is parallel with the costal margin over more than two-thirds of the wing, and then joins the costa. The base of the radius is not shown in the figures, except a very small portion in front of the point of origin of the radial sector, the latter arising in the basal third of the wing; beyond the radial sector the radius passes out to the wing-apex, keeping parallel with the costal margin.

The radial sector presents several difficulties. In neither of the two published figures is this vein depicted as we might expect. In all other respects the wing agrees remarkably closely with those of *Breyeria* and *Megaptiloides*, where the radial sector sends off inwards a series of simple branches, and runs out fairly parallel with the radius to the wing-apex. In place, however, of the radius passing straight outwards, it is represented as dividing into two branches in the distal fourth of the wing, the outer branch forking once and the inner forking twice. The inner branch of the radial sector diverges widely from the outer, and its three divisions go to the inner side of the wing-apex. A small branch is shown by Woodward as joining the radial sector to the first branch of the median, while the same branch is shown by Handlirsch as coming off from the radius immediately in front of its division into two, and passing down towards the inner margin between the inner branch of the radial sector and the first branch of the median, but not uniting to the latter. The median vein arises near the radius and sweeps out in a bold curve to the middle of the inner margin, giving off three outer undivided branches. Dr. Woodward, in his restoration of the base of the wing, has inadvertently indicated the main stem of the cubitus as joining the median. This is corrected in Handlirsch's drawing. The cubitus consists of a strongly curved stem giving off two branches, but only the inner marginal portions of the veins are present. The anal veins are three or four in number, and directed backwards at right angles to the length of the wing.

The interstitial neurulation consists of feeble transverse nervures, which either pass irregularly across between the main veins or occasionally fork.

Affinities.—Dr. Woodward doubtfully refers the wing to *Lithomantis carbonarius*, Woodw. Handlirsch, in the earlier part of his work, 'Die Fossilen Insekten' (p. 126), classed it as a "Palæodictyopteron" only, and afterwards, owing to its supposed relationship to *L. carbonarius*, and its evident likeness to *Lithosialis* and *Hadroneura*, established the genus *Stobbsia* for it, placing the species in the *Lithomantidæ*. There are, however, certain features of the wing which militate against his view. The close apposition of the costa, subcosta and radius are in marked contrast to the condition in that family, where these veins are widely spaced, and where there is also a very wide intercostal area. The radial sector is also more complex. In those details in which the wing departs from the *Lithomantidæ*, it approaches the characters of the genera *Breyeria* and *Megaptiloides*. The resemblances to *Megaptiloides brodiei*, Brong., and *Breyeria borinensis*, Borre, are very close, so far as can be determined by the distal fragment of the former wing and the more than three-fourths of the latter wing. The main difference between this wing and those of *Breyeria borinensis* and *B. lachlani* is in the character of the subcosta, which in the latter two species joins the radius. Whether the published figures of the Staffordshire wing are correctly drawn in this particular we do not know, and as we have already seen that these figures are

wrong in other details, we are compelled to assign the specimen to the family Breyeriidæ, and doubtfully to the genus *Breyeria*, with which it seems in agreement.

Family SPILAPTERIDÆ (Brongniart), Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 101.

Radial sector more or less branched; median divided into two main branches, the outer much divided; cubitus with an outer branch sending numerous twigs to the inner margin. Intercostal area occupied by a series of straight cross-nervures.

The family Spilapteridæ, founded by Brongniart in 1885, has been re-defined by Handlirsch and Lameere. The latter extended the group to include species which Brongniart had placed partly in the family Platypteridæ and partly in Protephemeridæ. All the forms thus brought together by Handlirsch agree in the possession of a typical palæodictyopteroid neurulation and the general characters enumerated above.

Lameere ('Bull. Mus. Hist. Nat. Paris,' 1917, no. 1), who rejects Handlirsch's views and classifications (see above, p. 15), has remodelled the family and given it a new significance. He is of opinion that the genera *Lamproptilia*, *Epitethe*, *Becquerelia*, *Palæoptilus*, *Compsoptera*, *Spiloptilus*, *Homalotoneura*, *Graphiptilus* and *Spilaptera* form a natural family, the Spilapteridæ, in which a progressive evolution in the longitudinal venation can be observed. The family is regarded as linked to that of Megasecopteridæ through the genus *Becquerelia*, and to the Protephemeridæ through the genus *Apoptopterus*. The three families are then grouped in his new order, Ephemeroptera. Such a classification is based on the belief that a perfect evolutionary sequence can be made out. Unfortunately, in presenting this classification, Lameere gives only a summary of his reasons and evidence, and it is not possible to criticise his argument. It is, to say the least, very doubtful if, in the present state of knowledge, we can judge relationships always correctly, while the sequence of evolution is still more difficult.

Handlirsch has acknowledged that he is unable to undertake any division of the family Spilapteridæ, as he understands it, and is content to await the discovery of the bodies of these insects for a fuller knowledge of the family. As the more rational view, Handlirsch's definition of the family is adopted.

Genus **SPILAPTERA**, Brongniart.

1885. *Spilaptera*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 63.

Generic Characters.—Insects closely resembling *Palæoptilus*; fore-wings narrower basally than the hind-wings; body slender.

Spilaptera sutcliffei, Bolton. Plate III, fig. 3; Text-figure 14.

1917. *Spilaptera sutcliffei*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 53, pl. iv, fig. 1, and text-fig.

Type.—Basal third of a wing; Manchester Museum (no. L. 8197).

Horizon and Locality.—Middle Coal Measures (grey-blue shales 135—180 feet above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire.

Specific Characters.—Subcosta parallel with the costal margin; median vein dividing near the base into two branches, of which the outer forks just beyond the point of origin of the radial sector. Cubitus a large and much-divided vein. Anal veins few in number.

Description.—This specimen was formerly labelled "*Stenodictya lobata*," and is one of three recorded by Sutcliffe, Baldwin, and others, in their papers on the fossils found at Sparth Bottoms. The remaining two are described (p. 37) under

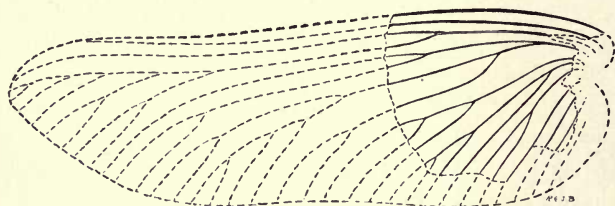


FIG. 14.—*Spilaptera sutcliffei*, Bolton; restoration of left wing, natural size.—Middle Coal Measures (shales above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire. Manchester Museum (no. L. 8197).

Mecynoptera tuberculata, Bolton. The specimen consists of the basal third of a wing lying on the median plane of a small irregular micaceous sandy nodule. The finer structure of the wing has not been preserved, owing, no doubt, to the coarse grain of the matrix. The chief veins of the wing are robust structures, and these are fortunately well marked and clear. The wing-fragment is 35 mm. in length along the outer margin, and 27 mm. in greatest width, but as the inner margin is broken away and lost, the total width of the wing exceeded this, and may have been over 30 mm. It belongs to a left wing, and when complete must have been at least 90 mm. in total length. The perfect insect must therefore have had a spread of wing of nearly 200 mm., or about 8 inches.

The outer margin is feebly convex, the subcosta fairly parallel, sunk in a groove, and gradually approaching the outer margin as it passes towards the wing-apex. The rate of approach is so gradual that the junction must have been far out near the wing-apex. The intercostal area is crossed by a series of straight nervures which are oblique in their course outwards.

The radius is strong, standing up above the surface, and almost parallel with the subcosta. The radial sector arises from the radius at about 22 mm. from the base of the wing. The median vein, owing to its inward direction away from the radial sector, is better shown. It forks very low down into two equal branches, both of which are widely spaced. The outer branch divides almost opposite the point of origin of the radial sector, while the inner branch forks much nearer the base of the wing, the innermost branch curving sharply back from its fellow, so that the area between them is wide almost from the commencement.

The general direction of the branches of the median is such that they would reach the outer half of the inner margin of the wing.

The cubitus consists of two main stems, the basal union being missing; the outer branch passes, after twice forking, in a double curve down to the inner margin of the wing, the inner branch being directed more directly backwards, and forking three times in the basal third. Fragments of four anal veins are distinguishable, the first dividing near the middle of its length into two equal branches. The interstitial neuration seems to have consisted of comparatively few straight and well-spaced nervures, some of which can be seen crossing the wide area between the innermost twig of the median and its fellow. No others are visible, except those in the intercostal area already mentioned.

Affinities.—Notwithstanding the fact that only about one-third of the wing is known, it is yet possible to determine the generic characters with a reasonable degree of accuracy. The mode of division of the radius and median, the manifest importance of the latter, the wide area between the median and cubitus, and the few widely spaced cross-nervures, are all typical Spilapteroid characters. The wing cannot be confused with that of *Stenodictya*, in which the median is much less developed, and the interstitial neuration closely reticulated. The only other genus to which it might be referred, that of *Becquerelia*, is distinguished by a union of the anal veins, which in *Spilaptera* and in this specimen are distinct.

Spilaptera has hitherto comprised only three species. From *S. packardi*, Brong., the specimen differs by the subcosta being parallel with the outer margin; by the equal separation of the subcosta, radius and median in the basal third of the wing; and by the division of the median into two branches close to the base of the wing. *S. libelluloides*, Brong., of which the distal half of the wing only is known, has a much feebler cubitus, which divides by forking further out than in *S. sutcliffei*. *S. venusta*, Brong., was established on a fragment much similar to that of *S. libelluloides*, in which the subcosta is a short vein, and the radial sector arises nearer the middle of the wing.

Family LAMPROPTILIDÆ (Brongniart), Handlirsch.

1885. Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 63.

1906. Handlirsch, Die Fossilen Insekten, p. 109.

Fore- and hind-wing strongly marked. Veins of the anal and cubital groups numerous and directed obliquely backwards. Hind-wings short and broad.

Genus **BOLTONIELLA**, Handlirsch.1885. *Lamproptilia*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 63.1919. *Boltoniella*, Handlirsch, Revision der Paläozoischen Insekten, p. 21.

Generic Characters.—Fore-wings two and a half times as long as wide; hind-wings as long as wide. Outer margin of former curved, of hind-wings almost straight. Apex of wings rounded. The fore-wings are almost elliptical, and the hind-wings rectangular in shape. The costa is marginal and the costal area somewhat narrow. The subcosta joins the costa far out. Radius simple, the radial sector arising near the base of the wing and giving off three forked branches, which pass obliquely to the inner half of the wing-apex. Median dividing into two main branches, the inner twice as much divided as the outer. Cubitus with two main branches, each breaking up into numerous twigs. Interstitial neuration consisting of widely spaced straight cross-nervures.

Handlirsch, who has formed this genus, admits that it reminds one in many ways of *Lamproptilia*, but by reason of the small size and closer spaced cross-nervures he separates it from that genus.

Boltoniella tenuitegminata (Bolton). Plate III, fig. 4.1911. *Lamproptilia tenuitegminata*, Bolton, Quart. Journ. Geol. Soc., vol. lxxvii, p. 170, pl. x, fig. 6.

Type.—A right hind-wing, in a small fragile block of brown mudstone or shale, crowded with plant-remains; Museum of Practical Geology, Jermyn Street, London (no. 24509).

Horizon and Locality.—Coal Measures (No. 2 Rhondda Seam, base of the Pennant Series); $1\frac{3}{4}$ miles north-east of Resolven Station, Glamorganshire.

Specific Characters.—Broad wings of great tenuity and blattoid-like in character. Principal veins much divided, and fading out on the inner margin. Apex of wing bluntly rounded. Anal veins very numerous.

Description.—The type-specimen consists of a right hind-wing of considerable tenuity, the underlying plant-remains being easily traceable through the texture of the wing. The greatest length is 29 mm., and the greatest breadth 7 mm. The neuration is so similar to that which I have observed in the hind-wings of blattoids

from Commentry, France, that it is difficult to refrain from classing the wing as blattoid. The neuration is extensively branched and the wing-boundaries are not well marked, but the wing appears to have been somewhat quadrangular in outline, with a sinuous inner margin, and the base much broader than is seen in the ordinary form of blattoid hind-wing. The outer margin seems to have been straight, a portion of it still remaining in the middle third. The two margins merge in a well-rounded apex. The subcostal area is narrow, strap-shaped, and probably extended over the whole length of the outer margin. No traces of cross-nervures can be seen on it. The radius divides near the base, giving rise to a series of branches which curve inwards as they approach the apex of the wing. The course of the branches is irregular, the interspaces widening and narrowing, possibly owing to the wing having crumpled during deposition. The median divides into two branches low down, each of which is repeatedly forked, the final divisions becoming attenuated and untraceable before the inner margin of the wing is reached. The course of the cubitus is obscured by a reed-like plant, only two basal portions being distinguishable. The anal area is filled by a broad series of thread-like veins, which sweep obliquely inwards in a fan-shape, and occupy a large part of the inner margin.

The inner margin of the wing to a third of its total length is quite filmy, the veins crossing the area as faint shadowy lines. The distal two-thirds is more strongly impressed, while in the broad base of attachment the stems of the principal veins seem to have been more than usually robust. No trace of transverse nervures or reticulation can be seen.

Affinities.—The nearest analogues to this wing are, I believe, the forms described by Brongniart as *Lamproptilia grand'euryi* and *L. stirrupi* ('Études sur le Terrain Houiller de Commentry,' vol. iii [1893], pp. 467—70, pl. xxxv [19], figs. 7—9). It appears to be more closely related to *L. stirrupi* than to *L. grand'euryi*, but is more quadrangular, and its costal area is broader. The anal portion of the wing is of greater tenuity, and occupies fully half of the inner margin.

Family BRODIDÆ, Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 113.

1919. Handlirsch, Revision der Paläozoischen Insekten, p. 73.

Wings in which the anal area is much reduced and specialised, the radius undivided, and the median, cubitus, and anal veins arched and directed back towards the inner margin.

From a re-examination of the originals in the British Museum, Handlirsch has concluded that the family does not belong to the Palæodictyoptera, but to the Order Megasecoptera. This view seems at variance with his own definition of the

latter Order ('Die Fossilen Insekten,' p. 312), where he states that the special distinctive characters of the Megasecopteridæ are the tendency to a reduction of the anal area of the wing, and the partial fusion of the median and cubitus with the base of the radius. *Brodia* certainly agrees with the Megasecopteridæ in the reduction of cross-nervures, but the anal area is very long, and I have not seen a single case among the twelve or thirteen specimens in the British Museum where there is any clear sign of fusion between the median, cubitus, and the base of the radius. The bases of the three veins are closely brought together in the inner spatulate portion of the wing, but this seems a natural result of the narrowing of the wing in this region.

The family Brodiidæ is more fully represented by individuals in the British Coal Measures than any other, thirteen specimens being known of *Brodia priscotincta*, Scd., alone. To this family also seem to belong a series of small larval wings. The neurulation in these is immature, and the wings themselves are far too small and weak to have supported the body in flight. The abdomen seems long and well segmented, the segments showing evidence of well-developed pleura, and they may also have borne tubercles. The whole integumentary structure is thin, and if at all chitinous, only feebly so, and but faintly outlined on the surface of the nodules. The wing-shape is much like that of *Brodia*, and the veins, so far as determinable, such as may reasonably be supposed to have developed into the typical *Brodia*-type in the adult.

While general evidence and association point to these wings being those of larval forms of *Brodia*, and possibly of *B. priscotincta*, Scd., it is more judicious to retain them in a distinct group. The same difficulties occur with other larval wings which cannot be allocated to known genera, and for which new generic names are not advisable. I therefore class larval wings of unknown relationship as a separate group under the name of "*Pteronepionites*," a name which has no classificatory value, but merely serves to indicate their larval nature. When evidence is forthcoming of the generic and specific relationship of any member of the group, it can be removed without the necessity of reducing a generic term which has passed into nomenclature to the rank of a synonym.

I would allot the term "*Pteronepionites*" to all larval insect-wings of all geological periods.

Genus **BRODIA**, Scudder.

1881. *Brodia*, Scudder, Geol. Mag. [2], vol. viii, p. 293.

Generic Characters.—Wings spatulate in shape, three times as long as wide. Outer margin feebly convex. Costa and radius spinulose, radius undivided, radial sector and median vein with few divisions. Cubitus a single vein. Anal veins few and widely spaced.

Brodia priscotincta, Scudder. Plate III, figs. 5, 6; Plate IV, figs. 1—3; Text-figures 15, 16.

1881. *Brodia priscotincta*, Scudder, Geol. Mag. [2], vol. viii, p. 293, text-fig.
 1883. *Brodia priscotincta*, Scudder, Mem. Boston Soc. Nat. Hist., vol. iii, p. 213, pl. xvii, figs. 3—7.
 1885. *Brodia priscotincta*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 63.
 1893. *Brodia priscotincta*, Brongniart, Faune Entom. Terr. Prim., p. 528, pl. xl (24), fig. 4.
 1906. *Brodia priscotincta*, Handlirsch, Die Fossilen Insekten, p. 113, pl. xii, fig. 13.
 1917. *Brodia priscotincta*, Bolton, Proc. Birmingham Nat. Hist. and Phil. Soc., vol. xiv, pt. 2, p. 100, pl. vii, figs. 3—4, text-figs. 2—3.
 1919. *Brodia priscotincta*, Handlirsch, Revision der Paläozoischen Insekten, p. 73, fig. 83.
 1919. *Brodia Scudderi*, Handlirsch, *op. cit.*, p. 74, fig. 84, Brit. Mus., no. I. 3879.
 1919. *Brodia petiolata*, Handlirsch, *op. cit.*, p. 74, fig. 85, Brit. Mus., no. I. 2961.
 1919. *Brodia pictipennis*, Handlirsch, *op. cit.*, p. 74, fig. 86, Brit. Mus., no. I. 2961.
 1919. *Brodia fasciata*, Handlirsch, *op. cit.*, p. 75, fig. 87, Brit. Mus., no. I. 1557.
 1919. *Brodia nebulosa*, Handlirsch, *op. cit.*, p. 75, fig. 88, Brit. Mus., no. I. 2961.

Type.—Incomplete wing; British Museum (Brodie Collection, no. I. 3896).

Horizon and Locality.—Middle Coal Measures (clay ironstone nodule from the binds between the “Brooch” and “Thick” coals); Dudley, Staffs. (Scudder gives the locality as Tipton).



FIG. 15.—*Brodia priscotincta*, Scudder; diagram of a complete left wing showing position of tubercles and character of neuration, natural size.—Middle Coal Measures; Dudley, Staffordshire.

Specific Characters.—Outer margin of wing spinulose, almost straight, or feebly convex at the most. Subcosta remote from margin at base, and extending beyond the middle of the wing, joining neither to the costa nor to the radius. Radius a strong vein, and spinulose. Radial sector arising in the first half of the wing, and giving off four branches. Median with two forward branches. Cubitus a single vein. Anal veins two. Inner margin strongly convex.

Description.—The Geological Department of the British Museum possesses no less than eleven examples of this species in addition to the type, while two more are in the Geological Collection of Birmingham University, one being in the Beale Collection, and the other presented by Dr. Blake. The British Museum specimens are registered as follows: I. 1557, I. 1567, I. 3879, I. 3896, In. 18431, all from Coseley; I. 2961, In. 18433, In. 18434, all from Tipton; In. 18429 from Sedgeley; and In. 18430, I. 5866, I. 2962, and In. 18432. The following description and remarks are based on a study of all these specimens.

The longest wing I have seen measures 58 mm. in length, and we are not likely

to be beyond the mark in estimating the total span of the insect as about 130 mm., or over 5 inches.

The outer or costal margin is straight, or feebly convex at most, over the greater part of its length, curving distally into the wing-apex. Close to the base it swells out into a slight hump-like elevation which is seen in all cases where the wing has been broken off close to the body. The whole of the outer margin bears a dense series of minute, conical, sharply pointed spinules of a black colour. These are arranged in two rows on the proximal half, with the points of the spinules directed towards the wing-apex. The bases of the spinules are expanded, and give a doubly corded or monilated appearance to the wing-margin. Tillyard regards these spinules as modifications of large hairs which he has termed "macrotrichia," and I see no reason to dissent from his view.

The subcosta at its origin is widely spaced from the outer margin, and passes out beyond the middle of the wing, gradually approaching, but failing to reach it. The subcosta is a strong, straight vein, the greater part elevated above the level of the wing-membrane, and distally flattening into it and disappearing.

The radius is a strong vein, more convex than the outer or costal margin, and therefore more widely separated from it at either end than in the middle. The basal portion is parallel with the subcosta for the whole length of the latter; it then becomes parallel with the outer margin for a short distance, and afterwards curves into the wing-apex. A single row of spinules can be distinguished along the whole vein in some specimens, and gives a slight monilation to the vein-surface. The radial sector is well marked, and comes off from the radius about the point of origin of the first forward branch of the median. The two veins are close together for some distance, but in the distal half of the wing they become parallel, the interspace being equal in width to that between the radius and the outer margin. The radial sector gives off four inward branches, which end on the inner side of the wing-apex. The first branch arises just beyond the middle of the wing, at an acute angle, and is separated from the second by an interval which is double the length of that separating the second and third. The fourth branch is very short, and so close to the margin as to be absent in some specimens.

The median vein for the first quarter of its course lies in the middle line of the wing, and then bends inwards in a wide curve to the distal third of the inner margin. It gives off two outward branches, both of which are larger and stronger than those of the radial sector. Both branches have the same sweeping curve possessed by the branches of the radial sector, and are parallel with the latter, while the main stem becomes almost straight.

The cubitus is a single vein, not united at the base to the median, and passing obliquely to the margin. Some wings have broken off so far out from the base that the cubitus appears to join the wing-margin at the junction of the middle and distal thirds. A striking feature of the cubitus is its isolated position upon the

margin, for while the interval between it and the stem of the median is much wider than any other in the fore-part of the wing, the interval between the cubitus and the next vein is nearly twice as wide. There is, in fact, a progressive widening between the veins as they are traced from the apex to the base of the wing, the areas between the median and its branches being wider than those enclosed by the branches of the radial sector.

Two somewhat dissimilar anal veins are present. The first has a wide curve to a point far out on the margin, sometimes giving off a short branch, while the second vein is much shorter and joins the margin at an acute angle. In some specimens this vein is seen to give off two, or even three, short oblique branches.

The shape of the wings is very similar to that of the wings of mosquitoes (*Anopheles*), and they bear evidence of having been folded in a plicate or fan-like fashion along their length. The first two folds are united at the wing-base, and pass out along the radius and the first outward branch of the median. The third fold lies along the line of the cubitus vein. The degree of plication which a wing retained when silted up modifies considerably the apparent distance between the several veins and their branches, and at times hides important junctions. In one example (Brit. Mus., no. In. 18431) the wing was well flattened out before being buried, and the origin of the veins and their true position can now easily be determined. This specimen shows that the radial sector arises much nearer the wing-base than the first outward branch of the median—a feature not usually shown in the remaining specimens.

The general build of the wing is such that the bases of the costal and subcostal veins on the outer margin, and those of the anal veins on the inner, must have served as the main support to the distal two-thirds of the wing, the latter consisting mainly of the radial sector and its branches, the median, and the distal half of the cubitus. Flight must have been mainly maintained by the action of this more distal expanded area, while the strain of movement would fall across the narrow neck-like base of the wing, and may ultimately have led to fracture and the loss of the wings. It is quite possible, also, that these insects were capable of finding food among the decaying vegetation of the coal forests, and thus prolonging life for a considerable period after the wings were lost. Such a presumptive sequence of events would account for the total absence of any trace of the bodies or legs, although the wings of this species are more numerous than any others in the Coal Measures and preserved in good condition.

Colour Bands.—Scudder mentions this species as the most striking instance among Palæozoic insects of the preservation of "colour bands," and as he states, some wings show three broad irregular belts of dull umber-brown colour across the wings. Close examination of these "colour bands" in the type-specimen, and in other examples, leads us to doubt the correctness of his view. In all cases where the "colour bands" do not show on the wings, the areas appear to be

totally destitute of any traces of the wing-membrane, and the course of the veins only is shown across the matrix. It is much more likely that the "colour-band" effect has been produced by conditions of preservation owing to the wing-membrane being destroyed in those areas which do not show colour.

Affinities.—Although Scudder founded both genus and species, he did not attempt any diagnostic description of either, confining his efforts mainly to a discussion of relationships. His figure is unusually poor, and adds nothing to the text. Scudder's general conclusion was that the wing was neuropteroid in character, but "refusing to affiliate closely with the restricted families of the present day." A manuscript note in Brodie's handwriting placed with the type-specimen would seem to show that Scudder's views acquired greater definition later. Brodie writes under date, February, 1880: "I sent this wing to Mr. Scudder, and he supposes it to belong to the white ants (Termitidæ), or close to the group of which Goldenberg's *Dictyoneura* is the best type." The first detailed descriptive note of the species was published in 1893 by Brongniart, with an

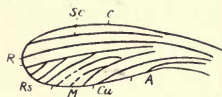


FIG. 16.—*Brodia priscotincta*, Scudder; immature wing, twice natural size.—Middle Coal Measures (clay ironstone nodule from binds between the "Brooch" and "Thick" coals); Coseley, Staffordshire. Madeley Collection, Brit. Mus. (no. I. 2966). A, anal; C, costa; Cu, cubitus; M, median; R, radius; Rs, radial sector; Sc, subcosta.

excellent enlarged drawing. Brongniart very doubtfully assigned the wing to the Protodonata, and "alongside the Campyloptera."

Immature Wings.—The collection of insect-remains which I describe later (p. 67) under the name of "*Pteronepionites*" were found at the same horizon and localities as *Brodia priscotincta*, and it is fairly certain that some of them are immature forms of this species. It will be noted that these larval forms are broad-bodied and well segmented, and with lateral outgrowths of a pleura-like character upon the abdomen. They indicate that *Brodia priscotincta* went through a progressive metamorphosis, the rudimentary wings gradually developing as the insects lived as ground-feeders among dank and rotting vegetation.

One of these wings (Pl. IV, fig. 3) in the Madeley Collection in the British Museum (no. I. 2966) is an impression 18 mm. in length by 4 mm. in maximum breadth, contained in a small grey ironstone nodule. As is usually the case with these grey nodules, the details of the wing are much obscured by the matrix, and the precise method of division of the veins is far from being clear.

The outer margin is regularly convex and formed by the costa. It gradually merges into the expanded and well-rounded wing-apex. The subcosta extends

the whole length of the wing, ending in the apex, and being parallel to the costal margin. A wide area separates it from the next vein.

The course of the radius is similar to that of the subcosta. The point at which the radial sector arises cannot be determined, but it lies in the base of the wing.

The radial sector is parallel with the radius over the greater part of its length, and gives off three inward branches in the distal third of the wing, all of which end on the inner side of the wing-apex.

The course of the inner third of the median is indistinguishable. The main stem reaches the middle of the wing before it gives off the first outer branch, which bends round and becomes parallel with the inner branch of the radial sector. The second branch arises a little further out, and at a more acute angle than the first, passing down to the inner margin of the wing midway between the first branch and the main stem.

The cubitus is a long undivided vein which passes, first in a curve, and then in a straight line to the inner margin.

Lying inward to the cubitus are traces of another undivided vein, which may represent the anal. It bends inwards more rapidly than the cubitus, and the interval between the two veins is very wide. The inner margin of the wing is sigmoidal in outline.

The general characters of this immature wing are unmistakeably those of the genus *Brodia*, and only the absence of spinules on the costal margin and radius, and the lack of a fourth branch to the radial sector, distinguish the specimen from adult wings of *B. priscotincta*. These details are not of specific value, and may be due to the immature condition of the wing, which is but one-third the length of that of a normal *B. priscotincta*.

The general characters of the wing are much like those of *Brodia priscotincta* (*juvenis*), and the specimen may be a slightly older larva of that form. The outline of the wing is much the same, but the branching of the principal veins is better shown and their apical curvature less pronounced.

The wing also lends considerable support to the belief that these insects did not possess a resting or pupal stage, but that the metamorphosis was regularly progressive.

Brodia priscotincta, Scudder, *forma juvenis*, Bolton. Plate IV, figs. 1, 2; Text-figures 17, 18.

1919. *Brodia nympha*, Handlirsch, Revision der Paläozoischen Insekten, p. 76, fig. 90.

Type.—A pair of wings, one almost complete, the other showing the apical half only; British Museum (Johnson Collection, no. I. 1563).

Horizon and Locality.—Middle Coal Measures (binds between the “Brooch” and “Thick” coals); Coseley, Staffs.

Description.—The fossil is contained in a brown ironstone nodule, the whole wing having a length of 21 mm., and a maximum diameter of 4 mm. It is membranous, and oblongate in shape. The outer wing-margin, of which only the distal half is preserved, is flatly convex and curves inwards, meeting the inner margin in a rounded apical angle. The inner margin is feebly concave. The wing has three longitudinal folds, and the extreme tenuity of the integument is accompanied by a corresponding thinness of the veins. The greater portion of the costa and the whole of the subcosta are missing. The outer portion of the radius is present. It is parallel with the outer margin, and curves round into the wing-apex. The radial sector is parallel with the subcosta, and curving round into the apex is lost, by reason of its tenuity. Lying inward to the main stem of the radial sector in the distal half of the wing are two long veins, and traces of two others, all following the same course, and curving to the inner margin. The two long veins

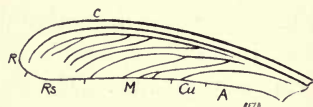


FIG. 17.—*Brodia priscotincta*, Scudder, *forma juvenis*, Bolton; diagram of wing-neuration, two-and-a-half times natural size.—Middle Coal Measures (binds between the “Brooch” and “Thick” coals); Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 1563). Lettering as in Text-figure 16, p. 62.

appear to arise from the radial sector, in which case the two of which traces only are seen would do so also. The radial sector therefore seems to give origin to four inwardly directed parallel branches. The whole course of the next vein is not clearly determinable. It passes to just beyond the middle of the inner margin, in an almost straight oblique course, and gives off a single forked outer branch parallel with the fourth branch of the radial sector. This vein can only be the median. The next vein is the cubitus. It is undivided, and goes to the middle of the inner margin. Anal veins are only indicated by feeble traces of a single undivided vein, which apparently reached the margin midway between the cubitus and the base of the wing.

Another similar wing from the same horizon and locality in the British Museum (no. I. 1564) is 17 mm. long and 5 mm. wide, and lies on the surface of a split nodule of dark-brown ironstone. The wing-membrane is very thin, and forms a slight glaze on the otherwise granulated surface—a feature which has made the details of structure difficult to determine. The costa is marginal, the outer margin convex, and gradually curving into the rounded apex of the wing. The inner margin is slightly convex distally, and straight proximally.

The subcosta is a feeble vein whose course cannot be traced with certainty

beyond the middle of the wing. It is close to the margin and parallel with it for its whole length. The radius is well marked, sunken, and also parallel with the margin except distally, where it is more inwardly curved. It ends on the apex in a short fork. The radial sector arises near the base, and is parallel with the radius. It appears to give off three to four branches, the first arising very near the base of the wing. The whole course of this branch can be traced, but of the middle two only faint traces are left in the region of the wing-apex. The fourth branch is very short, and corresponds in position with the last branch of the radial sector in *Brodia priscotincta*. The median vein forks low down into two equal branches, which reach the middle of the inner margin.

The cubitus is a long undivided vein passing out almost to the middle of the inner margin, and separated from the next vein, which seems to be the first anal. The course of the latter is more oblique to the inner margin than that of the cubitus.

In its general character this wing is distinctly similar to that of *B. priscotincta*, although it lacks a second branch to the median, and the first anal does not seem to be forked.

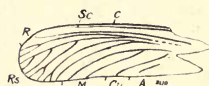


FIG. 18.—*Brodia priscotincta*, Scudder, *forma juvenis*, Bolton; diagram of wing-neuration, twice natural size.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffordshire. Madeley Collection, Brit. Mus. (no. I. 1564). Lettering as in Text-fig. 16, p. 62.

Affinities.—Handlirsch regards these as nymphal wing-sheaths, but their extreme tenuity militates against this view. He is probably wrong in referring *Brodia* to the Megasecopteridæ, but right in regarding these wings as those of heterometabolous insects, and not holometabolous as Lameere supposed.

Immature though the wings undoubtedly are, the more nearly perfect example possesses an assemblage of characters which I believe points to its relationship. The shape of the wing, the character and course of the subcosta, the number and position of the branches of the radius, the simple forking of the median and the anal veins, are all characters pertaining to the genus *Brodia*. The differences in detail between this wing and that of *B. priscotincta* are such as may be looked for between the nymph-stage and the adult. Among previously described larval wings, the only type which seems comparable is *Lameereites curripennis*, Handlirsch, based on four nymph-wings or wing-cases, as Handlirsch has them, found in the Coal Measures (Pennsylvanian) at Mazon Creek, Illinois, U.S.A. (1911, Handlirsch, 'Amer. Journ. Sci.' [4], vol. xxxi, p. 375).

In these wings, the outer or costal margin is more strongly curved, and the costa and radius extend over the bluntly curved apex down to its junction with the inner margin. The succeeding veins arise nearer the base of the radius, only one

apparently being a branch of that vein, while the median and the cubital areas are occupied by numerous veins whose origins are not indicated.

The differences between *Lameereites curvipennis* and this specimen are considerable. The balance of evidence is greatly in favour of an affinity with *Brodia priscotincta*, and the specimen may represent a nymph or larval stage of that species.

It is undesirable to attach a specific name to immature wings agreeing so closely with a known species. I propose to regard it as *B. priscotincta*, *forma juvenis*.

Brodia furcata, Handlirsch. Plate III, figs. 7, 8; Text-figure 19.

1919. *Brodia furcata*, Handlirsch, Revision der Paläozoischen Insekten, p. 75, fig. 89.

Type.—A left wing and impression showing the under-surface; British Museum (no. I. 2962).

Horizon and Locality.—Middle Coal Measures (above the "Brooch" Coal); Dudley and Coseley, Staffs.



FIG. 19.—*Brodia furcata*, Handlirsch; showing forking of the second branch of the median into two equal twigs, natural size.—Coal Measures (clay ironstone nodule from binds between the "Brooch" and "Thick" coals); Coseley, Staffordshire. Brit. Mus. (no. I. 2962).

Specific Characters.—Radial sector reduced in area, and possibly with three branches. Median having the second branch dividing into two equal twigs, both of which reach the margin. Median area enlarged.

Description.—This wing differs so much from the type-form as to be worthy of specific distinction. Its total length is 44 mm. and the greatest width 12.5 mm. The base of the wing is much more nearly complete than usual, and very narrow (5 mm.) for a short distance, beyond which it widens by the development of the strong convex inner margin. The wing shows the usual plication, which fortunately is not continued into its base, so that the course of the veins in the latter is not obscured, as is so often the case in *B. priscotincta*. The outer or costal margin forms an almost straight line, and bears a double row of spinules, those at the base of the wing pointing inwards. No basal hump, as in *B. priscotincta*, is shown. The subcosta is widely spaced from the outer margin proximally. The radius and radial sector present no special features, and but one inward branch is present. Whether four branches arose from the main stem, as in the type-species, cannot be determined owing to the loss of the apical portion of the wing. It is doubtful if such was the case, as the portion missing is not great. The outer three branches of the radial sector are usually 10—12 mm. apart, so that if the wing

possessed the same number of branches of the radial sector as in *B. priscotincta*, its total length would have been 70 mm.—an unusual length. The median vein is the most powerful of the whole series, and occupies a middle diagonal area equal in extent to the combined costal and radial areas. The first branch arises in line with the radial sector, and much nearer the base of the wing than in *B. priscotincta*, and also lies so much nearer the cubitus that the area separating the two is but half the diameter of the area in the former species. This shortening of the main stem and its movement inwards has been brought about by the division of the second branch into two equal twigs, which pass out to the margin between the first branch and the main stem. The median vein therefore takes a larger share in the wing-structure than in *B. priscotincta*, and the radial and cubital areas are correspondingly reduced. The cubitus presents no special features. Notwithstanding the shortening up of the area separating it from the median, the area between the cubitus and the anal veins is very large. The cubitus has suffered no displacement by the increased division of the median. The first anal vein is very long, passing well beyond the first third of the wing and dividing just before reaching the wing-margin. The second anal vein is two-thirds the length of the first, and bends inwards more gradually to the margin, giving off two short oblique branches in its basal half.

"PTERONEPIONITES."

Many larvæ of fossil blattoids have been recorded, but very few of other groups. These larvæ may eventually reveal the changes undergone up to the adult stage, and the development of the neururation of the wings. In addition, the occurrence of larvæ in deposits is more likely to be indicative of habitat than the presence of adult wings, as the inability of larvæ to fly and their lesser power of flotation would ensure inclusion in adjacent deposits. It is therefore necessary that their occurrence, and as much as possible of their structural appearance, be fully recorded. Any attempt to classify them under genera and species would rather retard than accelerate progress, and it seems advisable to record them under some term which will leave no doubt of their larval character. Handlirsch ('Amer. Journ. Sci.' [4], vol. xxxi, p. 375, 1911) has already described larval "wing-cases" of a somewhat similar character under the generic name of "*Lameereites*," and placed them under the order Megasecoptera.

Had not Handlirsch given a generic value to the name "*Lameereites*," it would have been possible to extend the use of his term to all larval wings. Failing this I would suggest the use of the word "*Pteronepionites*" for all larval wings which cannot be referred to a known genus, adding a specific designation when any larval wing presents features of a definitely recognisable character. Handlirsch restricts the name "*Lameereites*" to the wings of larval Megasecopteridæ, but recognises the

close similarity between them and *Pteronepionites* ('Revision der Paläozoischen Insekten,' p. 76).

"*Pteronepionites*" johnsoni, sp. nov. Plate IV, fig. 4; Text-figure 20.

Type.—Immature wing, 12 mm. long and 4 mm. wide; British Museum (Madeley Collection, no. I. 2967).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Description.—The wing, like all these immature structures, is of extreme tenuity, and the finer details are masked by the coarse granular nature of the matrix composing the nodule. The outer margin is straight, curving backwards until it meets the inner margin in a bluntly-pointed apex. The inner margin is strongly convex, a distal infolding indicating that the wing was apparently never fully extended. Very feeble traces occur of a short straight subcosta, which



FIG. 20.—"*Pteronepionites*" *johnsoni*, sp. nov.; diagram of wing-venation, two-and-a-half times natural size.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffordshire.—Madeley Collection, Brit. Mus. (no. I. 2967).

reached the margin near the apex of the wing. The radius is stout and straight and reaches the wing-apex, giving off a well-marked radial sector, which, diverging from the radius, passes in a wide curve into the wing-apex. The median remains undivided for nearly a third of its length, and then bifurcates into two equal branches which assume a parallel position, and reach the outer third of the inner margin. The cubitus is represented by two veins, the first having a sigmoidal sweep and the second a simple curve. Both reach the middle third of the inner margin. No trace of anal veins can be observed.

"*Pteronepionites*" ambigua, sp. nov. Plate IV, fig. 5.

Type.—A pair of larval wings still attached to the crushed and almost obliterated body; British Museum (Madeley Collection, no. I. 2968).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Description.—The insect lies in a fragment of a light grey ironstone nodule, and is not well preserved. One wing is whole, but more than half of the second is missing, and its apex is obscured by the matrix. The whole wing has a length of 6.5 mm. and a width of 2 mm. Each is much thickened over the basal half,

and strongly ridged or furrowed along the line of a powerful vein or tracheal trunk (the wing is so immature as to render the latter possible), occupying the position of the radius and median veins. Traces of a third vein occupying the position of the cubitus are present on the inner half of the wing. The body-segments are numerous, 3—4 mm. in depth, and seem to have had pleura-like expansions. The region in front of the thorax is bent backwards and below the abdominal segments. The thoracic segments are larger and more robust than those of the abdomen.

The thinness of the body, and the difficulty of determining boundaries with satisfactory accuracy, render all attempts at a more precise determination impossible. We can, however, say with confidence that the remains are those of an insect possessing a long segmented body, an elongated head-region, and wings carried upright over the back.

"Pteronepionites" lepus, sp. nov. Plate IV, fig. 6.

Type.—Remains of a larval insect, having a segmented body and two immature wings, in a flattened nodule of light-grey ironstone; British Museum (Madeley Collection, no. I. 2969).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Description.—The impression of two wings is clearly discernible, the segments of the abdomen are less so. With oblique lighting, six segments can be made out behind the thorax. The wings are slightly unequal in size, and the anterior is longer and thicker than the posterior wing; it is also somewhat infolded at the base. The differences between the two wings, and their relative positions, would seem to indicate that they are the fore- and hind-wings of the one side.

The fore-wing has a length of 9 mm. and a width of 2.5 mm., while the hind-wing is 8 mm. long and 2 mm. wide. The fore-wing has a strap-shaped appearance, and the line of attachment to the body is its broadest part. A stout ridge, swollen at its junction with the body, traverses the greater part of the length of the wing, dying out before the apex is reached. The wing is too small for definite determination of this swelling, but it appears due to incomplete extension of the wing-membrane, rather than to the presence of a vein. The distal fourth is flat and thin, and the apex well rounded. The outer and inner margins are parallel and undulated. A few faint and irregular lines may be indications of veins.

The hind-wing has undergone greater expansion than the fore-wing, and lies almost flat on the nodule. Both outer and inner margins are gently convex, the convexity of the inner margin being the greater. Feeble traces of a subcosta, and

of a stout vein which forks before the middle of the wing is reached, are distinguishable. The latter vein occupies the position I should assign to the radius. No further traces of veins are visible.

The two wings are separated by an interval of 3 mm. at their bases. No definite details can be made out in the thoracic region. Behind the hind-wing are faint impressions of a series of abdominal segments. These are about three times as deep as wide, and appear to have borne lateral spiny processes. There are also traces of tubercles.

The head-region is only indicated by faint discolorations. As in the case of other examples of "*Pteronepionites*" we have met with, the remains are so filmy in character, and merge so much into the matrix, that it is impossible to define the outer limits of the various segments with absolute clearness, and no attempt can be made at a systematic determination of characters.

The specimen is a larval form with wings not yet fitted for flight, but with a degree of differentiation in the fore-wings which indicates that they were thicker and less flexible than the hind-wings.

The abdomen is long, wide, and well segmented, the lateral expansions being not unlike those of *Euphoberia ferox*. So closely does the abdomen resemble the segmented body of a Diplopod, that in the absence of the wings we believe it would be readily classed as belonging to that group, and as possessing nothing in common with insects.

It is difficult to resist the belief that these larval insects were capable of crawling about in decaying vegetation, and that their larval life was thus spent, until by successive ecdysis the wings had acquired sufficient strength to lift the body from the ground, and enable the insect to fly.

Family ÆNIGMATODIDÆ, Handlirsch.

1906. Handlirsch, Proc. U.S. National Mus., vol. xxix, p. 683.

1906. Handlirsch, Die Fossilen Insekten, p. 116.

Wing strongly arched, and broadly rounded at the apex. Anal area small, and not marked off from the rest of the wing. Subcosta reaching almost to the wing-apex; radius simple, and radial sector with three divisions. Median with four branches. Costa represented by an oblique vein with a terminal fork, followed by three simple, strongly curved anal veins. Interstitial neuration partly of regular cross-nervures, and partly of a polygonal network.

Handlirsch founded this family on an incomplete wing in which the greater part of the outer border, subcosta and radius is missing. From the upper Middle Coal Measures of Mazon Creek, Ill., U.S.A.

Genus **ÆNIGMATODES**, Handlirsch.

1906. *Ænigmatodes*, Handlirsch, Die Fossilen Insekten, p. 116.

Generic characters as above.

Ænigmatodes (?) regularis, sp. nov. Plate IV, fig. 7; Text-figure 21.

Type.—Fragmentary wing; British Museum (no. In. 18,604).

Horizon and Locality.—Middle Coal Measures (over the Barnsley Thick Coal); Monckton Main Colliery, Barnsley, Yorkshire.

Specific Characters.—Radial sector, median, and cubital areas occupying most of the wing, and all with well-spaced branches united by straight nervures, except in the marginal area between the median and cubital veins where they form a slight meshwork. Inner margin well rounded.

Description.—Little more than half of this wing is preserved, and lies on a fragment of hard grey bind associated with broken-up plant-remains. The greatest length of the fragment is 42 mm., and the width 15 mm. The length

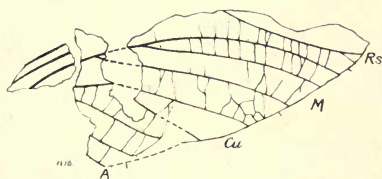


FIG. 21.—*Ænigmatodes (?) regularis*, sp. nov.; diagram of neuration of wing-fragment, one-and-a-half times natural size.—Coal Measures (over the Barnsley "Thick" coal); Monckton Main Colliery, Barnsley, Yorkshire. Brit. Mus. (no. In. 18,604). Lettering as in Text-figure 16, p. 62.

of the complete wing was probably 50–60 mm., and the width 18–20 mm. The outer margin is missing, and of the subcosta and radius only portions of the basal third are present. These are separated by a narrow area crossed by short transverse nervures.

In the distal third of the wing is the innermost branch of the radial sector, which ends on the margin in a small fork. The line of fracture of the wing has closely followed the line of the radial sector, and a portion of another branch of the radial sector may have been present along the line of the extreme broken edge of the wing. The median vein sweeps in a convex curve to far out on the inner margin, giving off two well-spaced branches. The next two veins, one of which forks, are more oblique in their course, and may also belong to the median, but the basal curve rather indicates that these veins are cubital, as is the succeeding vein, of which only a small portion is left. A trace of an anal vein is present near the wing-margin. The interstitial neuration consists of well-marked transverse nervures, regularly spaced in the outer parts of the wing, and uniting in a loose

meshwork in the wide area between the inner branch of the median and the cubitus.

Affinities.—The nearest approach to a wing of this character is that of *Ænigmatodes danielsi*, Handlirsch, in which the greater part of the outer margin is also missing. The Yorkshire specimen, which may be a hind-wing, is three times as long as *Æ. danielsi*, and the veins have a stronger inward curvature. In the absence of more definite details, it seems best provisionally to refer the specimen to the genus *Ænigmatodes*.

Genus **PSEUDOFOUQUEA**, Handlirsch.

1906. *Pseudofouquea*, Handlirsch, Die Fossilen Insekten, p. 125.

Wings three times as long as wide. Cubitus with inner and outer branches. Anal veins, so far as known, not united. Interstitial neuration of feeble cross-nervures except between cubitus and first anal, where it is irregularly reticulate.

Pseudofouquea cambrensis (Allen). Plate IV, fig. 8; Text-figure 22.

1901. *Fouquea cambrensis*, Allen, Geol. Mag. [4], vol. viii, p. 65, text-fig. on p. 66.

1906. *Pseudofouquea cambrensis*, Handlirsch, Die Fossilen Insekten, p. 125, pl. xiii, fig. 5.

1916. *Pseudofouquea cambrensis*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 59, pl. iv, figs. 4—5, and text-fig.

Type.—A broken left fore-wing, of which the two parts are preserved on fragments of black shale; one fragment, bearing the basal part of the wing, in the Museum of Practical Geology, Jermyn Street (no. 7272), the other, containing the impression of the distal 28 mm. of the wing, in the Welsh National Museum, Cardiff (no. 13,120).

Horizon and Locality.—Lower Coal Measures (top of the Four Foot Seam); Llanbradach Colliery, near Cardiff.

Specific Characters.—Wings stout and obtusely pointed. Costa marginal and flatly convex. Subcosta reaching margin in the outer third. Radius parallel with subcosta, and ending in apex of wing. Radial sector diverging widely from radius, and ending on the wing-apex in five divisions. Comstock regards it as a typical dichotomous radial sector, with an accessory vein on the second branch ('Wings of Insects,' 1918). Radius and radial sector occupying all the wing-apex. Median dichotomously branched, with an accessory vein in the fourth branch. Cubitus widely divergent from median, and giving off alternate twigs from its outer and inner sides, those of the inner side being much the feeblest. Anal veins four in number. Interstitial neuration of feeble cross-nervures, except between the base of the first anal vein and the cubitus, where it is irregularly reticulate.

Description.—The total length of the wing is now 32 mm., 9 mm. having been

lost from its tip since it was measured by Allen, who gives the total length as 41 mm. The greatest width is 15 mm.

The subcosta is widely separated from the outer or costal margin in the base of the wing, and gradually approaches and unites with it beyond the middle. The radius is parallel with the subcosta throughout its length, and gives origin to the radial sector basally. The radial sector diverges from the radius over the whole of its course. It now shows but one inwardly directed branch, which forks at the broken edge of the wing. Allen's figure indicates that two more branches were given off, both being undivided. The radius and radial sector occupied almost the whole of the apex of the wing.

The median vein forks in the basal fourth, the outer branch again forking before the middle of the wing is reached. The inner branch of the median diverges almost in a straight line from the outer branch, and also forks, and bears an accessory twig upon the fourth branch. A feeble accessory twig appears to be given off near the middle of the wing, but dies out in the integument. The cubitus



FIG. 22.—*Pseudofouquea cambrensis* (Allen): restoration of whole wing, natural size. Lower Coal Measures (top of the Four Foot Seam); Llanbradach Colliery, near Cardiff. Basal portion of wing in Mus. Pract. Geol. (no. 7272). Impression of apical portion of wing in the Welsh National Museum (no. 13,120).

is a remarkable vein, unlike that of any other fossil wing (Comstock, 'Wings of Insects,' 1918, p. 106). For nearly half its length it passes in a broad curve to the inner margin, giving off a series of alternate twigs upon its outer and inner sides, those of the inner being weaker than those of the outer side. The two outer twigs are strongly developed, while those on the inner side of the cubitus, four in number, are weaker and shorter. The feeble continuation of the main stem reaches the margin between the two sets of branches. Four anal veins are distinguishable. The inner two arise from a common base, the outer two not uniting. This is unlike the condition in *Fouquea*, where the anal veins branch off regularly from a single stem.

The area lying between the first anal vein and the main stem of the cubitus is very wide—much wider, indeed, than any other area.

The interstitial neuration consists of weak cross-nervures, except between the base of the first anal vein and the main stem of the cubitus, where it is irregularly reticulate.

Affinities.—The characters of the cubital and anal veins definitely remove the species from the genus *Fouquea*, and the cubitus, with its strong, anteriorly directed twigs, and its feebler inner series, is wholly unlike that of any other insect, and would alone suffice to justify the generic rank given by Handlirsch.

So far I am in agreement with Handlirsch, but I regard the enlarged areas between the inner divisions of the radial sector and the cubitus, and between the cubitus and the anal veins, as more suggestive of the Protorthoptera, notably *Thoronyxis ingbertensis*, Ammon. More than this cannot be said, and *Pseudofouquea cambrensis* must be regarded provisionally as Palæodictyopterid, with a possibility of Protorthopterid or even Orthopterid affinities.

INCERTÆ SEDIS.

Genus **ARCHÆOPTILUS**, Scudder.

1881. *Archæoptilus*, Scudder, Geol. Mag. [2], vol. viii, p. 295.

A wing of unusually robust type. Only one is known, consisting of not more than the basal fifth of a whole wing whose total length may have been 25·4 cm. to 35·5 cm. The fragment is too small for a correct determination of its systematic position, and has been referred to widely separated families by various workers.

Archæoptilus ingens, Scudder. Plate IV, fig. 9; Text-figure 23.

1881. *Archæoptilus ingens*, Scudder, Geol. Mag. [2], vol. viii, pp. 295, 300.

1883. *Archæoptilus ingens*, Scudder, Mem. Bost. Soc. Nat. Hist., vol. iii, pp. 217, 223, pl. xvii, figs. 10–12.

1885. *Archæoptilus ingens*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 60.

1885. *Archæoptilus ingens*, Scudder, Zittel's Handbuch der Palæontologie, vol. ii, p. 757.

1893. *Archæoptilus ingens*, Brongniart, Faune Entom. Temps Prim., p. 498, pl. xxxvii, fig. 6.

1906. *Archæoptilus ingens*, Handlirsch, Die Fossilen Insekten, p. 117, pl. xii, fig. 18.

Type.—Basal fifth of wing, in counterpart; British Museum (no. I. 3997).

Horizon and Locality.—Middle Upper Coal Measures; between Shelton and Clay Lane, near Chesterfield, Derbyshire.

Specific Characters.—Wings very large; costa, subcosta, and radius broad and robust. The costal border spiny. Interstitial neuration of stout transverse nervures.

Description.—Only the basal part of the wing and its counterpart are preserved, having a total length of 43 mm., and a greatest breadth of 33 mm. Scudder's estimate of the length of the whole wing as 35·5 cm. is probably excessive.

Scudder (*loc. cit.*, 1881) thus describes the specimen: "All the principal veins are a millimetre or more thick, and the cross-veins of the upper interspaces are tolerably distant, stout, prominent, and generally simple. The marginal (costa) vein, forming the front (outer) border of the wing is studded with short oblique spines (? macrotrichia). The other veins lie at very different levels on the stone,

and below the interspaces mentioned, seem rather closely crowded, and much more curved, sweeping downward, while the upper veins show little tendency to turn from a longitudinal course."

The great apparent width of the costa is caused by the formation of an expanded chitinous bar along its outer margin, the free edge bearing the spines described by Scudder. The costa, with its chitinous bar, the subcosta and the radius are so broad as to appear strap-like, are widely separated, and the intervening areas are crossed by equally strong nervures. The costa can be distinguished on the cast from the frontal bar and appears as a narrow rounded vein.

The subcosta is a very broad vein, crossed by oblique striæ which are directed outward from the upper edge of the vein. A broad interval (9 mm.) separates it from the costa, the area being crossed by stout, slightly oblique, transverse nervures. The general direction of the subcosta is such that it must have reached the margin of the wing near the apex. At the base it is much enlarged, the

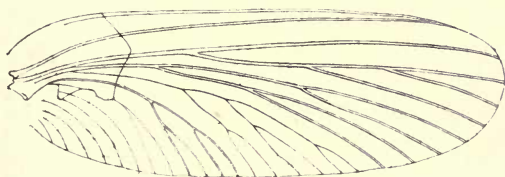


FIG. 23.—*Archæoptilus ingens*, Scudder; diagram of whole wing from Scudder's original restoration, one-quarter natural size.—Upper Coal Measures; near Chesterfield, Derbyshire. Brit. Mus. (no. I. 3997).

enlargement probably indicating the attachment to the body of the insect. The expanded inner portion of the base is fused with the equally expanded base of the radius.

The radius diverges from the subcosta in its outward course, and is even more enlarged than the subcosta. It is connected with the latter by a series of thirteen transverse nervures in the wing-fragment. Most of these are slightly convex, and two are united by lateral branching.

The median vein was apparently closely apposed to, or united with the base of the radius, and is much less robust than the latter, the intervening area being narrow, and crossed by short, thin, straight, transverse nervures which do not appear to continue into the base of the wing. The cubitus is not so readily distinguishable, and diverges sharply inwards towards the inner margin. The anal veins are 4—5 in number, and are strongly curved inwards, occupying not more than one-fifth of the inner margin of the wing. The first three may have been united at their base. The wing is marked by a series of folds along the lines of the principal veins.

Affinities.—This remarkable wing-fragment has caused considerable conjecture as to its true character and relationship. Scudder in his second note (*loc. cit.*,

1883) somewhat vaguely placed it, "with a strong degree of probability, in the same general group as some other Palæozoic wings." This reference can only be to the Palæodictyoptera. Later he published a restoration of the wing, and classed it with the Protophasmidæ. Brongniart at one time regarded it as a Dictyoneuron, and later as a "Neurorthopteron" of the group Sthenaropterida. Still later he placed it as a Neuropteron in the group Platypteridæ. Handlirsch considers that the costa is marginal, and that this character, with the sharp inward curve of the anal veins, justifies its inclusion in the Palæodictyoptera, although he does not attempt to indicate its allies.

A second species was described by Brongniart as *A. lucasi* ('Bull. Soc. Amis Sci. Nat. Rouen' [3], ann. xxi, p. 60, 1885), but this throws no light on the genus, nor does it appear to be generically referable to *Archæoptilus*.

The only details preserved which can be used in the determination of relationship are the spiny outer margin, the great width of the principal veins, the well-developed cross-nervures, and the strongly curved and numerous anal veins. Even these are too fragmentary for safe conclusions to be drawn in the absence of other material.

The general structure of the wing-fragment is to me more suggestive of the Protodonata than of the Palæodictyoptera, but the presence of well-marked anal veins discounts this view, unless we are prepared to accept the specimen as an early and archaic prototype of the Protodonata.

Order MIXOTERMITOIDEA, Handlirsch.

1906. Handlirsch, Proc. U.S. National Museum, vol. xxix, p. 695, and Die Fossilen Insekten, p. 126.
1919. Handlirsch, Revision der Paläozoischen Insekten, p. 26.

Subcosta much shortened; radial sector arising close to the base, with 2—3 branches, of which only one forks. Median long, four-branched and suggestive of the Palæodictyoptera. Cubitus with 2—3 inward branches. Anal vein 3, simple. Cross-nervures strong, wide-spread and regular.

This is a provisional order established by Handlirsch to include two forms only—*Mixotermes luganensis*, Sterzel, from the Coal Measures of Saxony, and *Geroneura wilsoni*, Matthew, from the Carboniferous of St. John, New Brunswick, North America. Both wings show clearly their Palæodictyopteroid ancestry, but Handlirsch is uncertain whether they should be brought near to the Protorthoptera or to the Perlidæ.

Genus GERONEURA, Matthew.

1889. *Geroneura*, Matthew, Trans. Roy. Soc. Canada, vol. vi, sect. iv, p. 57.

Generic Characters.—Wing three times as long as wide; apex obtusely rounded;

subcosta short and joining outer margin before middle of wing. Radius and radial sector occupying almost the whole of the wing-apex. Median, cubitus, and anal divisions few. Interstitial neuration of stout cross-nervures at wide intervals.

Geroneura (?) ovata, sp. nov. Plate V, fig. 1.

Type.—Portion of left wing; British Museum (Madeley Collection, no. I. 2965).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Specific Characters.—Radial sector rising in outer third of wing, with three divisions. Median vein large, the two outer branches forking in line with origin of the radial sector, the third branch undivided. Cubital veins few, undivided, and reaching the distal part of the inner margin of the wing.

Description.—The specimen consists of the impression of the upper surface of the distal portion of a left wing, having a length of 32 mm., and a breadth of 26 mm. The impression lies on the surface of a thin flattened half-nodule of fine sandy grit, and is but faintly indicated. The total length of the wing was probably from twice to three times the length of the portion preserved, and its breadth may have been a little more than 26 mm. The outer margin is gently convex, and curves into the broadly rounded apex. Very little is left of the inner margin, which also seems to have been convex. The distal portion of the costal margin is present for a length of 20 mm. There is no trace of the subcosta, so that this vein did not extend much, if at all, beyond the middle of the wing. The radius gives off the radial sector about the distal third of the wing, the two veins remaining almost parallel with the wing-apex. The radial sector gives off a single inward forked vein. The next three veins seem to be divisions of the median. The first two each give off an outer branch in line with the division of the radius and radial sector, and the outer of the two also forks before reaching the edge of the wing. The third vein is single for its whole length, but evidently united with the second a short distance outside the line of fracture of the nodule. The remaining four veins appear to belong to the cubitus. No anal veins are distinguishable. All the veins, with the exception of the small forks of the radial sector and first median, are parallel and widely spaced. They are united by a series of strong, straight cross-nervures placed widely apart. Notwithstanding the strength of the veins and of the cross-nervures, the smooth impression of the wing-fragment seems to indicate that the veins were not sunk below the general surface of the wing, as is usually the case.

Affinities.—The determination of the relationship of so small a wing-fragment would be difficult were it not for the unusual direction of the main veins, their mode of branching, and the character of the cross-nervures. These characters are a special feature of the order Mixotermitea, Handl.

The wing-fragment must be referred to this provisional order in the absence of knowledge of the whole wing-structure. The much-divided median vein is more comparable with that of *Geroneura wilsoni*, Matthew, than with that of *Mixotermes luganensis*, Sterzel, and is also correlated with a shorter subcostal vein, although in *G. wilsoni* that vein extends beyond the point at which the radial sector arises from the radius. An open series of cross-nervures is present in both genera, as in this specimen, and both have the same well-rounded apex. The wing-fragment is suggestive of *Hemeristia occidentalis*, Dana, but has a less branched radial sector. I provisionally refer it to *Geroneura* with the specific name of *ovata*.

Order PROTORTHOPTERA, Handlirsch.

1906. Handlirsch, Proc. U.S. National Museum, vol. xxix, p. 695, and Die Fossilen Insekten, p. 123.

1919. Handlirsch, Revision der Paläozoischen Insekten, p. 28.

Head large, with strong mouth-parts, and bearing long slender antennæ; prothorax large and elongated, and the body strongly built. Legs either uniform in character and fitted for running, or the hind-legs modified for leaping. Wings more specialised than those of the Palæodictyoptera, and capable of folding on the abdomen when at rest, with the enlarged anal areas of the hind-wings doubled under, owing to the formation of a fold between the anal area and the rest of the wing. The principal veins and their subdivisions not so strongly curved inwardly as in the Palæodictyoptera.

Handlirsch established this order to include a series of insects intermediate in character between true Orthoptera and Palæodictyoptera, to which Scudder had previously given the name of Palæodictyoptera Neuropteroidea.

Genus **ÆDÆOPHASMA**, Scudder.

1885. *Ædæophasma*, Scudder, Geol. Mag. [3], vol. ii, p. 265.

Generic Characters.—Large wings two-and-a-half times as long as wide; inner margin more convex than outer margin, and curving distally into the latter. Principal veins broad and flat in the basal third, and diminishing in size distally. Subcosta and radius reaching the wing-apex. Median vein with two main branches, the outer with most subdivisions. Cubitus with two main branches, each much subdivided. Anal veins numerous. Interstitial neuration of irregular nervures, and a loose meshwork in the wider areas.

Ædæophasma anglica, Scudder. Plate V, fig. 2; Text-figure 24.

1885. *Ædæophasma anglica*, Scudder, Geol. Mag. [3], vol. ii, p. 265, and in Zittel's Handbuch der Paläontologie, vol. ii, p. 758, fig. 941.

1906. *Ædeophasma anglica*, Handlirsch, Die Fossilen Insekten, p. 125, pl. xiii, fig. 4.

1916. *Ædeophasma anglica*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 43, pls. iii, iv, and text-figure.

Type.—Greater part of a left wing in an ironstone nodule; Liverpool Museum (presented by Major Chambers in 1858).

Horizon and Locality.—Middle Coal Measures; South Lancashire (locality unknown, but the nodule so similar to those derived from the Ravenhead Railway Cutting that it may be from that section).

Specific Characters.—As generic characters.

Description.—The specimen was partly described and named by Scudder in 1885, and re-examined and figured by the present writer in 1916.

The wing lies in counterpart in a fine-grained ironstone nodule, and its total length as now exposed is 87 mm., its greatest breadth (across the middle) 40 mm. When whole, the wing was probably 100 mm. long.



FIG. 24.—*Ædeophasma anglica*, Scudder; restoration of whole wing, showing the general character of the venation, natural size.—Middle Coal Measures; South Lancashire. Liverpool Museum.

The outer or costal margin is gently convex. The subcosta is a broad flat vein, gradually diminishing in width towards the wing-apex, which it just fails to reach.

The radius is an even broader vein than the subcosta, is also flattened in its basal third, and reaches the outer angle of the wing-tip, keeping parallel with the subcosta.

The median vein divides low down into two equal branches, the outer giving off four inwardly directed twigs. The first of these remains undivided; the second forks twice, and the outer and inner divisions of the second bifurcation again divide, so that the vein ends on the apical margin in six divisions. The remaining two branches are undivided. The divisions of the outer branch of the median occupy the greater part of the wing-apex.

The inner branch of the median does not divide until it has reached the apical fourth of the wing, where it gives off four twigs which pass inwards to the junction of the inner margin with the apex. Only the first of these twigs forks.

The cubitus has the same broad flattened basal portion which is so characteristic of the veins we have already dealt with. The main stem lies somewhat near

the first branch of the median, and remains parallel with it over almost the whole of its length. Inwardly it is separated somewhat widely from a slighter vein which, I believe, joined it near the base, and formed the first inward branch. The main stem sends off at the middle of the wing a strongly curved branch which bends first inwards and then outwards towards the apex, breaking up into five twigs before reaching the inner margin. The second of these twigs forks. A second undivided branch comes off a little further out, and a third very small one almost on the margin. The next two veins were probably united a little way out from the base, and their direction is such that the single stem from which they arose may have arisen, as suggested above, as the first inward branch of the cubitus. The outer of the two veins is undivided, and reaches the inner margin beyond the middle of the wing. The innermost vein runs fairly parallel with the first along its whole length, giving off, as it does so, four inwardly directed twigs, of which the first and fourth fork. The whole vein ends on the margin in six twigs. Four anal veins are shown, one only forking.

The interstitial neuration of the radial and median areas consists of straight or slightly curved nervures, placed at nearly equal distances. The very wide cubital and cubito-anal areas are filled by a loose meshwork, and a few irregular wavy nervures. The anal area is crossed by simple straight nervures.

Affinities.—Scudder was originally of opinion that this wing was related to *Meganeura* (*Dictyoneura*) *monyi*, Brong., representing a member of the group Protophasmidæ. Handlirsch removed the genus to the group Palæodictyoptera incertæ sedis.

Scudder was undoubtedly mistaken in referring the wing to the Protophasmidæ, as a glance at the figure of *Protophasma dumasii*, Brong., will at once show ('Die Fossilen Insekten,' pl. xvi, figs. 1—2). Handlirsch did not see the specimen, and had to base his determination on a sketch of the wing which he considered "confusedly drawn." The latter probably accounts for the interpretation which he placed on the various principal veins. More recently I have been able to expose more of the structure, and diagnosed the wing accordingly. If Handlirsch's view were correct, the radial sector would be of enormous proportions, and occupy all the wing-apex. The base of the radius, so far as shown, is widely divergent from the base of the median—more so, in fact, than at any other part of the whole course of the radius and supposed radial sector. These veins, therefore, have come into union only at the actual point of origin of the wing. This may have been the case, but in my opinion, the radius is wholly simple and undivided, and no radial sector is present. The median and cubitus are large, much divided, and take up the greater part of the wing-area, while the anal veins are few.

If this view be correct, the wing is a very primitive example of the Protorthoptera, still retaining evidence in the costa, subcosta and radius, of its Palæodictyopteroid origin.

Family COSELIIDÆ, nova.

A group of large-winged insects in which the principal veins are openly spaced; the radial sector joined by an outer branch of the median, and the median sending a strong inward commissure to the cubitus.

The family shows relationships with the *Ædischiidæ*, *Omaliidæ*, and *Cacurgidæ*.

Genus **COSELIA**, novum.

Generic Characters.—Costa and subcosta feeble, intercostal area very wide; radius straight; radial sector arising near middle of wing. Cubitus S-shaped, its branches occupying most of the inner margin of the wing. Interstitial neuration of transverse nervures uniting in some areas to form an open meshwork.

Coselia palmiformis, sp. nov. Plate V, fig. 3; Text-figure 25.

Type.—Basal half of a left wing in counterpart in an ironstone nodule; British Museum (Johnson Collection, no. I. 15893).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Specific Characters.—Subcosta united to radius basally, giving off numerous branches, united by irregular cross-nervures, to the outer margin. Radius strong, divergent from subcosta. Radial sector diverging from the radius. Median steadily divergent from radius and radial sector, and giving off an inner branch in the first third of the wing to the main stem of the cubitus. Beyond the middle of the wing, the median sending off several outer branches, the first uniting with the radial sector. Cubitus with its divisions extending over the greater portion of the inner margin of the wing. First anal vein strongly curved, the next thrice forked.

Description.—This species is represented by a little over the basal half of a left wing, 54 mm. long and 26 mm. wide, showing the under surface only. The outer or costal margin is convex and very thin. The costal area very wide at its base (6 mm.) and diminishing towards the wing-apex.

The subcosta is a feeble vein, apparently united basally to the radius, and passing outwards in a straight line towards the distal end of the outer margin, or into the outer part of the wing-apex. It gives off numerous branches to the outer margin, the branches being disposed regularly, and inclining apically in their course. They are joined by a few irregular cross-nervures, most of which are at right-angles to the branches of the subcosta.

The radius arises with an inward curve near the point at which the subcosta is given off, diverging from it and following a straight line to the wing-apex.

The radial sector arises near the middle of the wing, and at a distance of 38 mm. from the wing-base. The angle which it makes with the radius is fairly large, and the enclosed area must have been very wide in the outer half of the wing.

The median arises close to the radius, and then bends inwards as it passes to the inner half of the wing-apex. Its divergence from the radius is more than double that of the radius from the subcosta. Portions of two outwardly directed branches are shown, the first joining the radial sector; only the base of the second is preserved; it follows a course parallel with the first branch. About 21 mm. from the base the median gives off a strong inward branch passing obliquely to the cubitus and fusing with it. The cubitus is S-shaped, being convex outwardly to the junction with the commissural vein from the median, and concave inwardly afterwards. Owing to this inward inflexion, that part

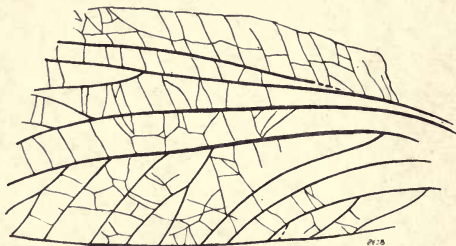


FIG. 25.—*Coselia palmiformis*, gen. et sp. nov.; diagram of basal portion of left wing, showing the general character of the venation, three-halves natural size.—Middle Coal Measures; Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. f. 15893).

of the cubital area lying beyond the junction with the median is extremely wide. The cubitus gives off four inwardly directed branches at wide intervals, the first branch having a wide forking in the first third of its length. The branches of the median must have occupied the greater part of the inner margin of the wing.

The cubitus gives off six inward branches, the first arising very low down, and the remaining five at regular intervals, the first being given off a little way beyond the junction with the commissural vein. The first and fourth of these branches fork into two widely separated twigs.

The first anal vein is simple, and has a broad convex outward sweep down to the inner margin; the second anal vein gives off three branches on its inner side. Other anal veins may have been present, but the wing-structure is missing at this point.

With the exception of the subcosta and radius, all the main veins are widely spaced, and no branches are given off, except the first median, in the basal third of the wing.

The interstitial neuration is well marked, and of unusual character. That

of the intercostal area has been already described; that between the subcosta and radius, between the radius and radial sector, and between the radial sector and the median, consists of a few irregular cross-nervures, one or two of which unite. In the median-cubital area the cross-nervures are joined up by longitudinal branches following a zig-zag course. A similar neurulation is seen between the inner branches of the cubitus, while the anal area is crossed by irregular cross-nervures occasionally uniting, as in the fore-part of the wing.

Affinities.—The general characters agree most closely with those of the *Cacurgidæ*, a family of insects which Handlirsch has described from ironstone nodules found in and around Mazon Creek, Illinois, U.S.A. It comprises insects which possess well-marked characters, but which, as a whole, Handlirsch is unable to assign with certainty to the Protorthoptera, or to the Protoblattoidea (Handlirsch, 'Amer. Journ. Sci.' [4], vol. xxxi, 1911, p. 323).

The wing of *Cacurgus spilopterus*, Handlirsch, has the same wide costal area; the radial sector arises far out, and the median gives off a commissural vein to the cubitus. The central portions of the median and cubital areas are also very wide, and the anal veins have the same strong inward curve.

The interstitial neurulation is much similar, but the formation of a meshwork has not proceeded so far in the British specimen as in *Cacurgus spilopterus*, where it is present between all the main veins, except the costal and subcostal. In the British specimen the meshwork is chiefly developed in the median and cubital areas. Areolæ are present in the wings of both species.

The differences between the wings of the two species are, however, important. In *Cacurgus spilopterus*, the first branch of the median does not unite with the radial sector, nor does it approach it very closely, whereas in the British wing, the first outer branch must have united with the radial sector. The median also branches again further out, the median in *C. spilopterus* having one outer branch only. *Lithosialis brongniarti* (Mantell) shows less affinity to the wing, but possesses the wide costal area, the same irregular and ramified interstitial neurulation, but a more complex median and simpler cubitus. The commissural vein is also wanting.

One other form with which a comparison needs to be made is *Omalia macroptera*, Van Beneden and Coemans. This species was obtained from the Westphalian (Middle Upper Coal Measures) of Hainault, Belgium. In its wing the costal area is wide, and crossed by oblique branches from the subcosta; the median sends an outer branch to join the radial sector, but there is no union of the median and cubitus. The interstitial neurulation is not mesh-like.

These wings are so similar that there seems no doubt they are closely related, but the relationship of the British specimen is closest with the genus *Cacurgus*.

Family *ÆDISCHIIDÆ*, Handlirsch.

1906. Handlirsch, Proc. U.S. National Museum, vol. xxix, p. 700, and Die Fossilen Insekten, p. 142.
 1919. Handlirsch, Revision der Paläozoischen Insekten, p. 39.

Radial sector coalescing with the main stem of the median, and branching as if a part of the latter vein.

Handlirsch regards the family as closely related to the *Sthenaropodidæ*.

Genus *GENENTOMUM*, Scudder.

1885. *Genentomum*, Scudder, Mem. Bost. Soc. Nat. Hist., vol. iii, p. 329.
 1893. *Edischia*, Brongniart, Faune Entom. Terr. Prim., p. 559.

Generic Characters.—Wings about three times as long as wide; principal veins and their branches well spaced, and united by a series of straight and well-defined nervures. Apex of wing obtuse.

Considerable doubt exists as to the true relationship of this genus, Scudder referring it to the *Homothetidæ*, Brauer considering it to have affinity with the *Sialidæ*, while Brongniart placed it with the *Ædischiidæ*.

Genentomum (?) *subacutum*, Bolton. Plate V, fig. 4.

1911. *Genentomum subacutum*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 334, pl. xxvii, figs. 18, 19.

Type.—Two small wing-fragments, 9 mm. in length, and 6 mm. in breadth; Bristol Museum (no. C. 972).

Horizon and Locality.—Lower Coal Measures (637 feet below the Bedminster Great Vein, and 137 feet above the Ashton Great Vein); South Liberty Colliery, Bristol.

Description.—One wing is partly superposed on the other, and the lower is also partially concealed by shale. The upper wing is represented by a portion of the distal inner portion, and by the wing-apex which is bluntly rounded. The outer margin is broken away, and the original size and shape of the wings cannot be determined.

The manner in which the wing-fragments are exposed on the shale renders systematic analysis of the neururation impossible. All the veins are narrow and sunk in the wing-membrane, while the interstitial neururation consists of transverse nervures arranged at right-angles, and dividing up the various areas into quadrangles. Where forking of the principal veins takes place, the resultant branches first diverge rapidly, and then pass outwards in parallel lines and at right-angles to the margin.

The lower wing-fragment shows a well-defined outer margin, evidently bounded by the costal vein. This margin is regularly and broadly convex, and shows signs of passing proximally into a straight or incurved line. The apex of the wing is narrow and bluntly rounded. The principal veins exposed appear to be portions of the radius, radial sector, and the distal branches of the median.

Affinities.—Fragmentary though these wings are, they nevertheless present features of unusual interest, as they are wholly unlike the blattoid wings found in the South Wales Coalfield, and are as yet the only insect-wings found in the Lower Coal Measures of the Bristol district.

The resemblance in venation and structure to locustid wings is remarkably close. There are the thin, sharply defined branch veins, and the division of the interspaces into rectangular areas by straight transverse nervures; and the texture is quite filmy, apart from the incised veins, as in *Locustidæ*.

Genus **XEROPTERA**, novum.

Generic Characters.—Wings more than three times as long as wide. Outer margin feebly convex. Subcosta ending far out. Radius reaching almost or to the wing-apex. Radial sector united by commissure to median. Median large, forming two main, equal-sized branches. Cubitus simple. Interstitial neuration of numerous straight cross-nervures.

Xeroptera obtusata, sp. nov. Plate V, fig. 5; Text-figure 26.

Type.—A right fore-wing in counterpart in nodule; British Museum (Johnson Collection, no. I. 1558).

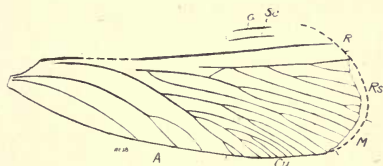


FIG. 26.—*Xeroptera obtusata*, gen. et sp. nov.; diagram of venation of wing, three-halves natural size.—Middle Coal Measures; Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 1558). Lettering as in Text-figure 16, p. 62.

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Description.—The wing is not complete, the whole of the outer margin being missing, or hidden by the matrix; the apex is raggedly torn, and much of the

inner margin is missing. So far as preserved it is 41 mm. long, and 16 mm. in greatest breadth.

The fore-wing lies on a hind-wing which is partly traceable, and both have been crumpled together, some of the veins of the hind-wing showing through the fore-wing. This renders the unravelling of the venation difficult, while the fragmentary condition of the stems of the main veins in the basal part of the wing hinders the definite determination of their course, and their relation to one another.

A small portion of the distally outer or costal margin has been uncovered sufficient to show that it was slightly convex. Close to the margin is a trace of the subcostal vein, proving that it continued well towards the wing-apex, if it did not reach the latter.

The outer part of the wing has been torn away along the area separating the subcosta and radius, and the latter vein is seen to traverse the whole length of the wing, but whether it joined the outer margin distally or came out on the wing-apex is not discernible.

The basal half of the radius is confused with the basal portions of the median and cubitus veins, owing to the crumpling which the wing has undergone. The radial sector arises in the basal half of the wing and diverges from the radius, a wide area separating the two. Soon after its origin it receives a branch from the median, and immediately afterwards gives off the first of three inwardly directed branches, the middle one soon dividing into two equal twigs, while the first branch forks on the margin. These divisions of the radius and the radial sector occupy the whole of the outer part of the wing-apex. The first branch of the radial sector probably represents the union of two twigs of the radius and median, and the small marginal fork may also represent their separation.

The median vein is incomplete basally, and appears to be large and much divided. Apparently it separates early into two main branches, the first dividing into two almost equal twigs, which again fork, the outer branch of each fork going forwards as an oblique commissure and joining the vein next in front. This is a somewhat unusual feature. The course of the outer twig after its juncture with the stem of the radial sector we have already traced. The outer twig of the second branch of the median, after fusing with the inner twig of the first branch, is probably continued by the inner of the two later divisions formed by that twig. The third branch of the median passes obliquely inwards, giving off an outer twig which forks twice, and, beyond the middle of the wing, gives off outer and inner branches from one point, afterwards forking twice before it reaches the inner margin of the wing. The whole structure ends in fourteen divisions on the distal half of the inner margin, and occupies a considerable area of the whole wing. It is possible that this complex of branching veins represents the median and cubitus combined, but I do not think it likely. If such be the case, the first branch given

off from the main stem is the median with four ultimate divisions, plus a branch to the radial sector, all the rest forming a much-divided cubitus with outer branches.

If this interpretation is correct, the next veins in the series are anal. Unfortunately, these are far too broken and uncertain in character to supply any evidence on the point. The first vein has a bold sweep from the base of the wing well outwards towards the middle of the inner margin, and seems to divide into a wide fork before reaching it. The second vein is simple, and may also fork, but low down, although it is impossible to say whether or no the forked appearance is due to a fold of the crumpled wing. If the two veins present are anal, then the anal area is very large, and the divisions of the cubitus are directed so as to lie almost wholly in the distal half of the wing. This appears unlikely. The divisions of the cubitus are usually simple, or but once forked, and usually directed inwards, ending normally on the middle of the wing-margin. The vein is united to the undoubted median stem and has a similar mode of branching, while its position on the margin is in the distal half. I see no reason, therefore, to regard this vein as a cubitus. The next vein, with its bold semicircular sweep to the margin, has the character of a cubitus, and so I regard it.

The second more incomplete vein may also be a cubital vein or the first anal. The interstitial neuration consists of a numerous series of straight cross-nervures.

The wing is thin and membranous.

Affinities.—The salient features of this wing include the union of the median with the radial sector and of one branch of the median with another, the considerable branching of the median and its extension on to the inner margin, the reduced cubitus, a small anal area and the long spatulate shape of the wing.

These general characters belong in varying degrees to a group of families, among which may be instanced the *Ædischiidæ*, *Sthenaropodidæ*, *Spanioderidæ*, and *Geraridæ*. The genus *Becquerelia* has the same development of the median, and in *B. superba*, a fusion of an outer branch of the median with the radial sector; but the wing is widest across the anal region, and the cubitus has a correspondingly increased development.

With *Schuchertiella* and *Gerarus* the relationship is perhaps closer, as in these genera the median is large and much divided, and the cubitus correspondingly reduced. Material differences debar a reference of the specimen to any of these families. I would assign it a position close to *Ædischiidæ*, in which the outer margin is nearly straight, the wing-apex rounded, and the median and radial sector united. Dr. Tillyard has suggested to me that the wing be compared with his archetype wing of the *Panorpoid* complex. There certainly appears to be a relationship, but this wing is specialised beyond the archetype, and too fragmentary for definite conclusions to be drawn from it. It cannot be referred to *Ædischiidæ*, however, because in that genus the subcosta is longer, the cubitus shorter, and with fewer twigs. I have therefore formed for it the new genus *Xeroptera*.

Genus **SCALÆOPTERA**, novum.

Large wings, 60 mm. or more in length. Costa marginal and slightly curved. Subcosta widely separated from margin and giving off straight, oblique and widely-separated branches to the margin. Radius parallel with the subcosta, and giving off the radial sector in the basal half of the wing. Median with few divisions. Cubitus long, with few divisions. Wing feebly plicate. Interstitial neuration forming a fine, close reticulation.

Scalæoptera recta, sp. nov. Plate VI, fig. 1; Text-figure 27.

Type.—Basal half of left wing in counterpart, having a length of 29 mm., and a width of 14 mm.; British Museum (no. I. 13878).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Description.—The inner margin of the wing is lost or concealed in the matrix,

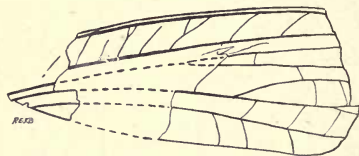


FIG. 27.—*Scalæoptera recta*, gen. et sp. nov.; diagram of the basal half of wing, twice natural size.—Middle Coal Measures; Coseley, Staffordshire. Brit. Mus. (no. I. 13878).

while the anal area, and possibly a part of the cubital area, is missing. A portion of the nodule containing the distal half of the wing is lost. The total length of the wing could not have been less than 60 mm., and judging from its apparent relationships, may have been more.

The surface of the wing is slightly plicated, two low ridges bearing the radius and principal branch of the cubitus, while the subcosta and the median are deeply sunk. Its membranous portion is strongly coriaceous, with stout cross-nervures at wide intervals. The outer margin and the principal veins are feebly spinulose, as best seen on the radius and radial sector. The outer margin is feebly convex, the fairly straight course of the margin, and of all the principal veins, pointing to the wing being much longer than wide; a view also borne out, as we shall see later, by its possible relationships.

The subcosta is widely removed from the margin, parallel with it, and giving off a series of stout branches passing obliquely outwards to the margin. Of these divisions, one only is clearly forked.

Two portions of the radius are present, a short basal portion, and a second piece further out. The vein is separated from the subcosta by an interval less

than half that separating the subcosta and the margin. It lies also on a ridge which increases in strength distally. The radius and subcosta are parallel. The actual point of origin of the radial sector is not shown, but can be determined within narrow limits. It arises almost in the basal fourth of the wing, and so far as its course can be traced, diverges from the radius.

The median diverges along its whole course from the radius, and gives off on its outer side two branches, which remain undivided to the broken edge of the nodule. The first branch arises in line with the origin of the radial sector, and at an acute angle which soon enlarges, so that the interval separating it from the radial sector is less than half that separating them at their origin.

The cubitus divides into two nearly equal branches very low down in the base of the wing, the second branch sending off a short division against the broken edge of the nodule.

The stem of the median, and the two branches of the cubitus, have a parallel course, like the outer margin, subcosta and radius, the widening interval between the two groups of veins being occupied by the radial sector, and the two outer branches of the median. The direction of the subcosta, radius, radial sector, and first branch of the median, indicates that they traversed almost the whole length of the wing and ended on the wing-apex. The main stem of the median and the branches of the cubitus would reach the distal half of the inner margin. There are no traces of anal veins.

Affinities.—The extreme width of the intercostal area, the marked divergence of the costa, subcosta and radius from the median and cubitus, are features not readily recognisable among other known fossil insects. The few widely-spaced cross-nervures are not wholly peculiar to the specimen. Similarly, the spinulose principal veins are paralleled by those of *Brodia priscotincta* and *Archæoptilus ingens*. I have not seen so marked a coriaceous texture in any British fossil insect. The length of the wing-fragment before branching of the principal veins occurs, implies a long and relatively narrow wing. Such a wing-form is seen in the Palæodictyoptera and in the Protorthoptera. The wing differs from that of *Brodia priscotincta* in its much greater size, in the presence of a well-developed series of cross-nervures, and in the coriaceous surface of the wing-membrane. The direction of the radial sector and the divisions of the median vein are unlike those in *Brodia*, where these veins curve steadily from their points of origin inwards to the wing-margin.

Two groups of insects described by Handlirsch ('Amer. Journ. Sci.' [4], vol. xxxi, 1911), from the Pennsylvanian Series of the Carboniferous of Mazon Creek, Ill., under the family names of Spanioderidæ and Geraridæ, appear to resemble most nearly the wings we are considering. The wings in these families are long and narrow, and obtusely rounded at the apex, and the principal veins, especially in the Spanioderidæ, pass straight out for the whole, or the greater

part, of their length. Their costal area is also broader than the subcostal-radial area, and in both families the interstitial neuration consists of straight cross-nervures, except in the costal area, where they are oblique, as in this specimen.

These resemblances, however, are not sufficient to justify the inclusion of the new wing among the Geraridæ, because they are accompanied by equally or more important differences, such as the spinulose character of the principal veins, the great development of the intercostal area, the marked divergence of the stems of the radius and the median, the coriaceous wing-membrane and the much fewer cross-nervures. The wing, too, possesses quite a leathery texture, while the cross-nervures are broad and flat, forming conspicuous details of the surface.

With our present knowledge, it is only possible to infer that the wing is related to the Geraridæ and Spanioderidæ, that it is a Protorthopteroid, and that it still retains traces of its Palæodictyopteroid ancestry.

Order PROTOBLATTOIDEA, Handlirsch.

The Protoblattoids have a well-rounded head, a prothorax showing little or no expansion, and the wings intermediate in type between those of Palæodictyopteroids and Blattoids. The anal areas of the fore-wings or tegmina¹ are well marked out, and crossed by arcuate or oblique veins reaching the inner margin, while those of the hind-wings are enlarged and marked off from the rest of the wing by an anal fold. The body is more slender than in the majority of Blattoids.

The members of this order form a connecting link between the Palæodictyoptera and the Blattæformes. In many respects there is a close resemblance between the members of the order and those of the Protorthoptera, and the two may have arisen from nearly related stocks.

Genus **PTENODERA**, novum.

Generic Characters.—Subcosta reaching almost to the wing-apex. Radial sector twice furcate; median well divided, with its minor divisions crowded on the inner half of the wing-apex.

I have formed this genus to include a wing-fragment of unusual character in which the principal veins are long, and directed towards the wing-apex with few divisions, and the interstitial neuration consists of straight cross-nervures. The specimen shows that the branching of the principal veins is much similar to that of *Polyetes* among the Protoblattoidea, and to that of *Spanioderia schucherti*, Handl., among the Protorthoptera, in this respect supporting Pruvost, who has established

¹ The thickened rigid fore-wings of Blattoids are usually termed "tegmina."

a sub-order, Archiblattides, to receive many of the insects classed as Protorthoptera by Handlirsch.

The wing is apparently related also to *Scalæoptera recta*, Bolton, and as the latter shows no trace of the formation of an anal lobe, I class this genus with the Protorthoptera rather than with the Protoblattoidea. The Protoblattoidea probably arose from a Protorthopteroid stock.

Ptenodera dubius, sp. nov. Plate VI, fig. 2; Text-figure 28.

Type.—Distal half of a left wing, on the split surface of one half of an ironstone nodule; British Museum (Johnson Collection, no. I. 1559).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

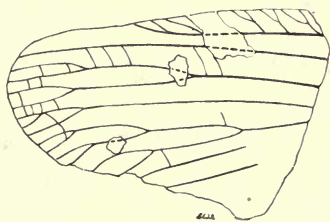


Fig. 28.—*Ptenodera dubius*, gen. et sp. nov.; diagram of apical portion of wing, twice natural size.—Middle Coal Measures; Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 1559).

Description.—The ironstone nodule has been broken across, and that portion which contained the basal half of the wing has been lost. The distal portion of wing remaining is 27 mm. long, with a width of 16 mm. across the widest part. The width of the basal half of the wing was probably greater.

The distal half of the wing is thin and membranous, and a little wrinkled. The principal veins are well shown, but the interstitial nervures are only clearly visible when the nodule is immersed in water.

The costa is marginal and gradually curves into a well-rounded wing-apex. The subcosta is widely spaced from the costal margin basally, and gradually approaches it as it passes out towards the wing-apex, which it does not reach. It gives off to the wing-margin a series of oblique divisions, several of which fork.

The radius is simple, and passes straight to the wing-apex. Somewhat widely separated from the radius is the radial sector, which must therefore have been given off low down in the base of the wing. It divides into two equal branches, each of which is again equally divided, so that it ends on the middle of the wing-apex in four divisions.

The median vein is large and well branched. The nodule has been broken

across just beyond the point of division of the two main branches. The outer branch remains undivided until near the margin, where it forks twice, ending on the inner side of the wing-apex in three divisions. The inner branch forks into two equal twigs, the outer breaking up twice by equal forking into four divisions, while the inner twig forks once. Most of the divisions of the inner branch of the median end on the distal portion of the inner wing-margin.

Two incomplete branches of the cubitus are present, but the character of the vein cannot be determined. No traces of the anal veins are shown.

The principal veins and their main branches are well spaced, and follow the same general direction without being truly parallel. The interstitial neuration consists of fine straight cross-nervures.

Affinities.—The general character of the veins other than the subcosta is seen in several Palæodictyopteroid genera such as *Eubleptus*, but in none that I know are these characters accompanied by a similar type of subcosta. In the oblique, forked divisions of the latter, and the manner in which they are given off, as well as in the course of the subcosta itself, the wing most resembles that of the Protoblattoids, and to this group I would assign it.

INCERTÆ SEDIS.

Genus **PLESIOIDISCHIA**, Handlirsch.

1906. *Plesioidischia*, Handlirsch, Die Fossilen Insekten, p. 346.

Plesioidischia sp. Plate VI, fig. 3; Text-figure 29.

Type.—A fragment of a right wing, 40 mm. long and 10 mm. wide; Manchester Museum (no. L. 4905).

Horizon and Locality.—Middle Coal Measures (binds between "Brooch" and "Thick" coals); Tipton, Staffs.

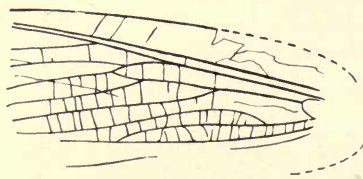


FIG. 29.—*Plesioidischia* sp; diagram of venation of wing-fragment, three-halves natural size.—Middle Coal Measures; Tipton, Staffordshire. Manchester Museum (no. L. 4905).

Description.—The wing-fragment lies on the irregular surface of a small ironstone nodule, the outer costal margin and costal area on one half of the nodule, and the middle portion of the wing on the other. The base

and apex of the wing are missing, or still concealed in the matrix. Few definite factors are presented for determination, and the following description is the best we can give.

The outer margin of the wing is formed by the costa, and seems to be curved basally and straight distally. The costal area is widest at the base, and gradually narrows by the approach of the subcosta, which doubtless reached the outer margin far out. The costal area is crossed by a few stout straight branches of the subcosta. The subcosta passes straight from the base to the distal portion of the wing-margin.

The radius is close to and parallel with the subcosta. It gives off two inward diverging branches, the first uniting with the median, but giving off a secondary branch before it reaches the latter. The median gradually diverges from the radius. It gives off two well-marked inner branches, and then bends forwards to join the first branch of the radius. The point of union of the two branches gives origin to a backward twig parallel with the secondary branch of the radius, and with the two inner branches of the median.

The cubitus is represented by a long oblique vein going down to the inner margin. It gives off near its base an outer branch, which curves inwards parallel with the main stem, and reaches the wing-margin much beyond it. The wing appears to have broken along the level of a succeeding vein, but whether this was also a cubital or an anal vein it is impossible to determine.

The interstitial neuration consists of a series of stout strong cross-nervures. The texture of the wing seems to have been membranous.

Affinities.—The chief features of the wing are the strong parallelism of the veins, the numerous and strong cross-nervures, and the unusual mode of union of the radius and median. This assemblage of characters serves to place the specimen in the Protorthoptera, but it is not referable to any known genus, and is too incomplete to justify a new genus for its reception. The nearest approach appears to be *Progenetomum carbonis*, Handl., in which the subcosta reaches the middle of the wing, the radial sector unites with the median, and the interstitial neuration is of straight cross-nervures.

Order BLATTOIDEA.

The most numerous and varied insects found in the Coal Measures are the Blattoids, the recorded forms being classified in several families, embracing nearly 100 genera and 400 species. The early history of their study is dealt with by S. H. Scudder ('Mem. Bost. Soc. Nat. Hist.,' vol. iii, pt. 1, no. 3, 1879), and need not be repeated here.

Notwithstanding the abundance of specimens and forms known, they are insufficient for a satisfactory classification of the group, and do not provide the

stages in the life-history of any species. Handlirsch has recorded the occurrence of several egg-cases of Blattoids from the Carboniferous ('Proc. U.S. National Museum,' vol. xxix, p. 716, 1906). Larval forms have been described by Scudder, Handlirsch, Woodward, and especially by Sellards ('Amer. Journ. Sci.' [4], vol. xviii, p. 113, 1904), but in all cases the remains are too incomplete for satisfactory study.

The Coal Measure Blattoids show unmistakably that the race had a much earlier ancestry, as they depart widely from the Palæodictyopteroid type, and have attained a high degree of specialisation. The eggs were enclosed in capsules (Ootheca) much as in modern cockroaches, and the development was by a progressive metamorphosis, in which the rudimentary wings were formed at a relatively early stage, and increased in complexity of structure and size at successive ecdyses. It would also appear that the rudimentary wings were attached to the thorax by broad bases, and that the formation of an articular joint was not developed until the adult stage was reached. The elements of the thorax were as well developed in Coal Measure times as they are to-day, both in structure and function, while the legs, as seen in examples from Commeny (Allier), France, were long, spiny, or covered with stiff hairs, and well adapted for walking or running.

The wings display a remarkable diversity of neurulation. The fore-wings are invariably modified by the formation of chitin into stout, horny structures, usually termed "tegmina," which served to protect the more delicate membranous hind-wings concealed beneath them. The costa is always marginal.

The hind-wings are not well known. When found, they are thin, membranous, larger than the tegmina, and folded beneath them. The enlargement of the wing has taken place over the inner half, the costal and radial areas being reduced, and the anal area not marked off from the rest of the wing by a furrow, as is seen in the fore-wings or tegmina. The wide variation in the neurulation of the tegmina furnishes the only satisfactory data for classification. Assuming, as we must, that the Blattoids were derived from the Palæodictyoptera, the simplest form of Blattoid must be that in which the wing-neurulation most nearly approximates to the latter type. This principle is the basis of Handlirsch's classification.

Modification of the wing-membrane for flight in the case of the hind-wings has brought about, or been accompanied by, a narrowing of the costal and radial areas, a reduction in the strength and extent of these veins, and an increased development of the median and cubital areas, coupled with an increased growth of the wing-membrane inwardly. The hind-wing is, therefore, a much more asymmetrical structure than the fore-wing or tegmen.

The abdomen is broad, somewhat flattened and well-segmented, but no positive evidence is known of an invagination of the terminal segments to carry the

egg-capsule. Cerci are present, and Sellards has identified long ovipositors, though this identification is not accepted by Handlirsch.

The habits of Carboniferous Blattoids can only be inferred from those of living forms. I have previously (p. 11) drawn attention to the occurrence of Blattoid wings among the leaves of *Cordaites* bearing numerous shells of the small annelid, *Spirorbis pusillus*, and suggested that the Blattoids frequented decaying vegetation to feed on the *Spirorbis* and similar organisms.

The tegmina of *Phylomyacris mantidioides* occur among masses of the spat ("Ancyclus rintii") of *Anthracomya phillipsii* in coal shales of the Durham Coalfield. Most of the other Blattoid remains from the Coal Measures of this country have been found in sedimentary deposits in which Ostracods also occur. Apart from these facts, the general faunal associations of fossil insects to which I drew attention on pp. 18—24 are, I think, of great importance, as furnishing definite clues to habits. The same Arthropod-association still persists, and the lagunal and marshy phases of the Coal Measures would furnish a fitting and desirable environment for the whole series.

Classification.—The classification of the Carboniferous Blattoids is difficult, owing to lack of material. The known British forms are few in number, and have been found in several coalfields at horizons which cannot be correlated with each other or placed in a regular sequence.

Scudder's classification does not sufficiently take into account the relationship which undoubtedly exists between the Blattoids and the Palæodictyoptera, and it is based mainly on a knowledge of living forms. For this reason, probably, the Mylacridæ are placed as the first tribe in his group "Palæoblattariæ," in preference to the Archimylacridæ, in which a Palæodictyopteroid relationship is more clearly evident.

Handlirsch's classification gives greater attention to the ancestral type, and is also based on an examination of more numerous specimens than were accessible to Scudder. It is far from satisfactory, and will certainly be much modified when the collection of several thousand Blattoid remains from Commentry is fully worked out by Prof. Meunier, whose results are not yet published. Lameere's general classification ('Bull. Mus. Hist. Naturelle,' 1917, no. 1) is too uncertain to justify adoption.

Dr. P. Pruvost, who has given several years to a close study of the fossil Blattoids of the French and Belgian Coalfields, has modified Handlirsch's classification, and in his latest memoir (1920) he classifies the Blattoidea of Northern France as follows:

BLATTOIDEA.

Family ARCHIMYLACRIDÆ.

Genera *Actinoblatta*, *Manoblatta*, *Archimylacris*, *Asemoblatta*, *Phyloblatta*, *Grypoblattina*, *Archæotiphe*, *Barroisiblatta*, and *Mesitoblatta*.

Family MYLACRIDÆ.

Genera *Hemimylacris*, *Phylomylacris*, *Trilophomylacris*, *Soomylacris*, *Lithomylacris*, *Orthomylacris*, *Stenomylacris*.

Family POROBLATTINIDÆ.

Genus *Premnoblatta*.

This classification seems to accord most nearly with recent discoveries, and is therefore adopted here.

Family ARCHIMYLACRIDÆ, Handlirsch.

Body slender in primitive forms, broadened out in more specialised types. Cerci well developed and jointed. Legs slender and armed with spines. Antennæ slender. Pronotum subcircular. Subcosta distinct, with pectinate or equally spaced branches. Radius well branched, with or without radial sector. Median of one or two main branches. Radius, radial sector and median with outward branches only. Cubitus inwardly curved, and with inward branches. Anal furrow present. Anal area large, extending beyond the basal third of the wing. Interstitial neurulation of straight nervures, or an irregular reticulation, or the two combined.

The greater number of Palæozoic Blattoids belong to this family, which is united to the Palæodictyoptera by transitional forms.

Genus **APHTHOROBLATTINA**, Handlirsch.

1906. *Aphthoroblattina*, Handlirsch, Proc. U.S. National Museum, vol. xxix, p. 719, and Die Fossilen Insekten, p. 183.

Generic Characters.—Tegmina two-and-a-half times as long as wide, with convex outer margin. Costal area narrow and strap-shaped. Subcosta extending over two-thirds the wing-length. Radius giving off radial sector near middle of wing, and sending a few simple branches to the apex. Radial sector forking into four or six branches. Median small, with few branches directed inwardly. Cubitus giving off 7—8 branches along its whole length, and extending well out towards the wing-apex. Anal area small.

Aphthoroblattina johnsoni (Woodward). Plate VI, figs. 4, 5; Text-figures 30, 31.

1887. *Etblattina johnsoni*, Woodward, Geol. Mag. [3], vol. iv, p. 53, pl. ii, figs. 1 a, 1 b.

1906. *Aphthoroblattina*, Handlirsch, Die Fossilen Insekten, p. 183.

Type.—The pronotum and tegmina in an inverted position with traces of hind-wings on a small ironstone nodule, in counterpart; British Museum (Johnson Collection, no. I. 1067).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Specific Characters.—Tegmina slightly convex and expanded towards the apex, about two-and-a-quarter times as long as wide. Apex broadly rounded. Costal area occupying three-fourths of the outer margin of the wing. Subcostal vein weak. Radius almost straight and giving off the radial sector about the middle of its length. Radial sector doubly furcate. Median vein widely spaced across the middle of the wing. Cubital vein reaching the inner angle of the wing-apex, giving off outer and inner branches. Anal area large, and crossed by a few small anal veins. Hind-wings thin, larger than the tegmina, and with strong veins.

Description.—The elucidation of the neuration of the wings of the type specimen is difficult, owing to the venation of the hind-wings being impressed

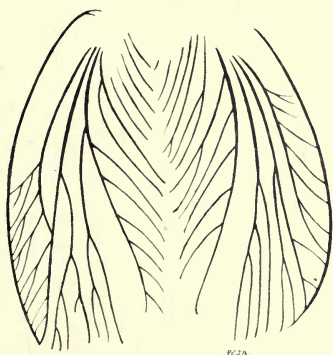


FIG. 30.

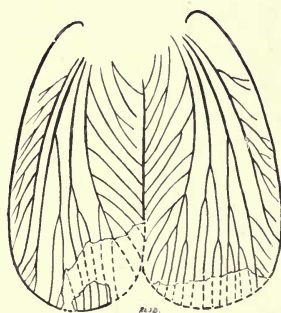


FIG. 31.

FIG. 30.—*Aphthoroblattina johnsoni* (Woodward); diagram of venation of the two fore-wings of the type-specimen, twice natural size.—Middle Coal Measures (binds between "Brooch" and "Thick" coals); Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 1067).

FIG. 31.—*Aphthoroblattina johnsoni* (Woodward); diagram of venation of the fore-wings of a normal example of the type-series, twice natural size.—Same horizon and locality as Fig. 30. W. Egginton's Collection, "no. 2."

on that of the tegmina. The veins of the hind-wings are stronger than the distal portions of those veins of the tegmina which they overlie. It is probably owing to these factors that the original figures of the type are incorrect.

In both tegmina, as indicated by Dr. Woodward, the median and cubitus are shown as united, whereas this union takes place in the left wing only. Neither of the figures gives an adequate indication of the presence of the hind-wings. In the larger figure the radius and cubitus are represented by a single vein, which is also incorrect. Allusion has already been made to the wings lying on the smaller portion of the nodule in an inverted position. This is demonstrated by the pronotum, which dips under the mesonotum into the matrix, and by the deep impressions of the veins of the hind-wings crossing over, and not under, the veins of the tegmina. The veins of the tegmina are also in relief, instead of being sunken as they normally are on the dorsal surface.

The pronotum has a diameter of 13 mm., and 8 mm. of its length is exposed. The sides curve evenly backwards, and show no sign of flattening, so that its general shape is semicircular. The hinder border is hidden, and disposed at an angle to the surface-plane of the wings. The presence of a sunken, central, pyriform area on the inner surface of the pronotum probably marks the position occupied by the head of the insect. The downward inclination of the front margin of the pronotum, and the elevation of the hinder border, is a frequent feature in the Coal Measure Blattoids.

During life a small gap interposed between the pro- and mesonotum, and this became filled up by sediment on burial in sufficient quantity to cause the pronotum to be lifted from the body of the insect by that half of the nodule which carries the wing-impressions. This inclined position of the pronotum is so common that it appears to have been normal.

The mesonotal area is covered by the anal areas of the tegmina, and its character cannot be determined.

The venation of the right tegmen differs considerably from that of the left. The under surface of the latter is the more nearly perfect, and the venation is more distinct. The costal margins of the tegmina form two broad arcs, sharply bent inwards at the base, and distally merging into the wing-apex. The left subcosta is widely separated from the margin, giving off three oblique branches which fork, the first twice, before reaching the margin. Beyond these branches, the left costa curves inwards and unites with the main stem of the radius at the distal third of the wing. The right costa is more normal, and does not unite with the radius. It gives off six outward branches, of which only the first is forked.

The left radius, after a slight basal curve, passes straight out to the apex, giving off four forward branches, the first forked. This first forked branch appears to be the continuation of the subcosta. The radius of the right tegmen gives off two simple outer branches only.

There is a wide difference between the radial sectors of the two tegmina. That of the left divides in the middle of its length into two equal branches, which in turn fork, the outermost twig forking again, so that the radial sector ends on the margin in five divisions. The right radial sector forks once only beyond the middle of its length, and ends on the margin in only two divisions.

The median in each tegmen is a comparatively simple vein, that of the left being united with the cubitus in the basal fourth, and separating from it at an acute angle. Beyond the middle of the wing it gives off a single forked branch on its outer side. These divisions of the median, with the first branch of the radial sector, occupy the inner half of the apex. The median of the right tegmen is well separated from the cubitus along its whole length, and passes in a bold curve to the inner half of the apex, giving off four simple outer branches.

Apart from its union with the stem of the median, the cubitus of the left

tegmen agrees fairly well with its fellow. Both veins curve inwards, and reach the junction of the inner margin with the apex, and both give off 6—7 branches inwardly, the first branch in each case forking.

Which forward branches were given off on the outward side of the cubitus in the left tegmen cannot be made out, but faint furrows on the right tegmen seem to indicate that three simple outer veins were present.

The anal area is long and acutely ovate, extending over nearly a third of the inner margin. Six anal veins are present, the distal one with a strong fork.

The interstitial neururation consists of stout, straight nervures, not always well shown. The inner margin is nearly straight.

The veins of the hind-wings are very fragmentary. They are much thinner than those of the tegmina, and have left a much slighter impress. They appear to consist of a straight costa, separated by a very narrow area from an equally straight subcosta, below which can be made out a portion of the radius, radial sector, and median.

All the veins are widely spaced, and the breadth of the hind-wings must have been about double that of the tegmina.

The dissimilarity between the neururation of the left and right tegmina in the type-specimen suggests a wide varietal range among Coal Measure Blattoids, a feature which needs to be taken into account in the definition of species.

The presence of these abnormalities in the type-specimen somewhat militates against its value for reference, and I therefore add other details from a second example which I received from Mr. W. Egginton. The specific characters given above have been drawn up from this specimen, which lies in a small ironstone nodule, marked "No. 2," having a length of 43 mm. and a breadth of 38 mm. The Blattoid has a total length of 33.5 mm., and a maximum breadth across the tegmina of 24 mm. The inner margins of the tegmina overlap, evidently in their position of rest during life.

The pronotum, apparently in natural position, lies a little out of the horizontal, the front margin dipping downwards, and the hinder margin upwards and a little forwards, so that a slight gap occurs between it and the wings. This feature we have already alluded to, and in this case the pronotum has been carried away as usual, but the wings remain, so that the wing-impressions with the pronotum are on the upper surface of one half of the nodule, the other half carrying the pronotal impression and the wings.

The pronotum is 12 mm. wide and broadly rounded, only a little more than half being visible. It shows a central raised area, oval in outline, and defined from the margins by lateral grooves. The meso- and meta-notal segments show as a low, flat, elongated, heart-shaped region overlain by the anal areas of the tegmina.

Both tegmina are still attached high up on the sides of the body. So far as can be determined through the substance of the tegmina, the hind-wings are

attached nearer the middle line, and almost on the upper surface. All four wings are present, the tegmen of the right side being perfect, while that on the left has lost a portion of the inner part of the apex. The right tegmen is 25 mm. long, and 12 mm. wide at its broadest part.

The costal margin is broadly arcuate, and merges into a well-rounded apex. The subcosta is feeble, and gives off 7—10 very oblique branches, each breaking up into numerous twigs before reaching the margin. The intercostal area is wide and strap-shaped, and occupies the greater part of the outer margin.

The radius is well separated from the subcosta at its base, and diverges a little from it along its course. It gives off the radial sector before the middle of the wing is reached, and then passes forward undivided until near the end of the subcosta, where it gives off four or more short oblique branches forward.

The radial sector diverges strongly from the radius, and, like the latter, remains undivided for the greater part of its length. In the last third it gives off two, possibly three, outer twigs, which fork before reaching the margin. The inter-radial area at the point where the first branch arises is very wide.

The median arises close to the radius, but soon bends strongly towards the inner side of the apex. It gives off three outer parallel branches, the first of which forks.

The cubitus is a powerful and large vein, well apart from the median at its origin, and passing above the middle of the wing in its proximal third, beyond which it curves inwards to the end of the inner margin. It gives off six simple branches and ends in a feeble fork, while two strong branches arise on the outer side and pass to the apex.

The anal area is large, occupying one-third of the margin, and containing six anal veins, the first, second and third forking.

The inner margin is almost straight. The interstitial venation consists of numerous raised cross-nervures, best seen in the anal and cubital areas. In the radial and median areas the cross-nervures unite laterally and occasionally fork.

Portions of the hind-wings are present, but only the distal branching of the radial sector, median and cubitus is shown beyond the broken end of the left tegmen. The course of the radius and median is traceable across the surface of the tegmen of each side.

The wing-membrane is so thin as to be scarcely discernible.

Aphthoroblattina eggintoni, sp. nov. Plate VI, fig. 6; Text-figure 32.

Type.—Pronotum, tegmina and portions of hind-wings lying on the surfaces of a split ironstone nodule; "No. 1" in the Collection of Mr. W. Egginton.

Horizon and Locality.—Middle Coal Measures (beds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Specific Characters.—Costal margin convex. Cubitus long, strap-shaped, and extending almost the whole length of the outer margin. Radial sector with few simple branches. Median vein forking three times, and ending in middle and inner side of the wing-apex. Cubitus extending the whole length of the inner margin, with no evident outer branches, and feeble forking.

Description.—The specimen is contained in a small greyish-brown nodule, 48 mm. long and 35 mm. wide, and lies with the dorsal surface of the wings and the impression of the pronotum on one half of the nodule, and the wing-impressions and pronotum on the other half. The remains are in good condition, and show a small portion of the head, the pronotum and mesonotum, almost the whole of the left tegmen, and the basal two-thirds of the right tegmen, while a portion of the left hind-wing is disclosed over that area from which the fragment of the

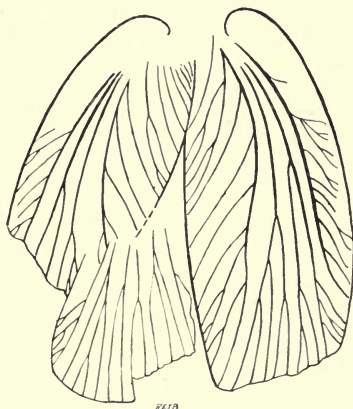


FIG. 32.—*Aphthoroblattina eggintoni*, sp. nov.; diagram of venation of fore-wings and portion of left hind-wing, twice natural size.—Middle Coal Measures (binds between "Brooch" and "Thick" coals); Coseley, Staffordshire. W. Egginton's Collection, "no. 1."

tegmen is missing. That both hind-wings are present is indicated by their principal veins showing in feeble fashion through the tegmina.

The head is small, not more than 3 mm. of its length being visible, and not all of this would be seen were the front margin of the pronotum intact. The latter has been broken away in the middle line, and allows a portion of the head to become visible. The hinder part of the head is well rounded and narrowed, the front being wide, and having a forward and downward slope. It is finely tuberculated. A small aperture in the middle of the head may be due to a loss of matrix.

The pronotum is attached to that half of the nodule which contains the wing-impressions, and the hinder border is still covered with the matrix. Its whole contour cannot be seen, and only the inner surface is exposed. It is semi-circular, with a well-defined margin, 12 mm. wide, and 8 mm. long from front to

back. The central area has a deep median furrow, and is marked off from the lateral halves by two ridges (representing the furrows on the dorsal surface). These ridges converge anteriorly and almost meet. The inner surface is slightly concave, and indented by three faint furrows on each side, parallel with which are traces of fine striations.

The mesonotum is 4.5 mm. long, and much wider anteriorly than posteriorly. It is convex, and the hinder border has a raised rounded edge. It is strongly chitinous, much more so than the metanotum, which is crushed down beneath the anal areas of the tegmina, only a little of the hinder portion of the left side showing at one point where the anal areas of the wings have been broken away. The right tegmen lies in the position of rest, its inner margin being in line with the axial line of the body. The left tegmen was rotated outwards to a slight degree before entombment—a feature which, combined with the breaking away of its distal third, has enabled the left hind-wing to be better shown. The right tegmen has a length of 33 mm. and a breadth of 13 mm.

The costal margin is moderately thickened, convex, and merges gradually into the wing-apex, the latter bluntly rounded.

The subcostal vein is thin, and encloses a long strap-shaped area, crossed by 9—10 oblique branches, most of them forking twice before reaching the margin.

The radius is a strong vein, nearly parallel with the subcosta, and ending on the outer margin in four small branches, the second only forking. The radial sector arises just before the middle of the wing, diverging but slightly from the radius. It gives off three short outward branches to the apex.

The main stem of the median passes along the middle line of the wing for some distance, and curves inwards to the distal end of the inner margin. The first outward branch arises a little beyond the middle of the wing, and forks into two equal-sized twigs; the remaining two branches remain undivided to the broken edge of the wing. The median and its subdivisions occupy the centre and inner half of the wing-apex.

In the left tegmen the second branch of the median forks. The cubitus is strongly convex in the proximal two-thirds, and bends forwards in the distal third and inwards again to the inner margin. It gives off six inward branches, the fourth and fifth forking before reaching the margin. The anal veins are eight in number, three being very small and short. The first forks twice, and the second once. The inner margin is almost straight. The interstitial neuration is made up of straight nervures. The surface of the tegmina is chitinous.

The hind-wings appear not only to have been covered by the tegmina, when they were in a position of rest on the body, but to have stretched a little beyond them like a fringe.

The left hind-wing is thin and membranous, and marked by numerous veins, the bases still hidden under the tegmen. A little of the distal portion of the

costal margin is shown, passing into a very broad and expanded apex. The subcosta reaches nearly to the end of the costal margin, and gives off numerous oblique and forked branches. Immediately behind the subcosta is a stout vein with two outer branches, both forking. This vein seems to be the radius. Its basal extension under the tegmen can be traced by a raised line. Behind the radius are two stout veins, each of which forks into equal-sized twigs some distance from the margin. Their position justifies the inference that they unite proximally and join the radius, in which case they must belong to the radial sector. The median is a doubly forked vein. The remainder of the wing is either bent under, or folded upon itself, and further details cannot be made out.

Affinities.—The species differs from *Apthoroblattina johnsoni* in several important details. The radial sector arises further out, and instead of forking twice, gives off three simple forward veins. The median forks three times, the proximal branch forking again before reaching the wing-apex. In *A. johnsoni* there are two branches, both of which fork. The cubitus vein differs considerably owing to the fact that the main stem divides at the outer third into two branches of equal strength, the outer immediately forking again into two equal twigs, while the inner gives off a small inner twig. No definite outer branches are distinguishable. A strong anal furrow is present, and the first anal vein on both sides divides into three twigs, the remaining 5—6 anal veins being undivided.

Genus **ARCHIMYLACRIS**, Scudder.

1868. *Archimylacris*, Scudder, in Dawson's *Acadian Geology*, ed. 2, p. 388.

Generic Characters.—Tegmina twice as long as wide, with convex outer margin. Inner margin concave. Radial sector arising in basal half of wing. Anal veins few, anal area large. Neuration of abundant stout straight cross-nervures.

Archimylacris hastata, Bolton. Plate VII, fig. 1; Text-figure 33.

1911. *Archimylacris (Etoiblattina) hastata*, Bolton, *Quart. Journ. Geol. Soc.*, vol. lxxvii, p. 160, pl. ix, figs. 1—3.

Type.—The greater part of a left tegmen and its counterpart, showing the upper surface; Museum of Practical Geology, Jermyn Street (nos. 24501 and 24502).

Horizon and Locality.—Upper Coal Measures (Gellideg Level of the Mynyddislwyn Vein); near Maes-y-cwmmwr, Monmouthshire.

Specific Characters.—Wing broadly elliptical. Costal margin convex; costal area broad at base and stretching beyond the middle of the wing. Subcosta with numerous branches, all oblique. Radius forking twice, and ending near

apex of wing. Median branching further out than the radius. Cubitus reaching margin in distal third of wing. Anal veins numerous. Inner margin almost straight.

Description.—A portion of the base of the wing and a considerable part of the apical and inner margin are missing, but the length preserved is 33·4 mm. and its breadth is 16·5 mm.

The wing is strongly outlined, especially along the outer margin, partly owing to a broad concave depression which runs almost the whole length of the subcostal and radial areas, causing the anterior margin to be reflexed dorsally. The inner margin is preserved only along a portion of the anal border, and the inner two-thirds of the wing-apex are also missing. Sufficient is left of the apex to show that it must have been bluntly rounded.

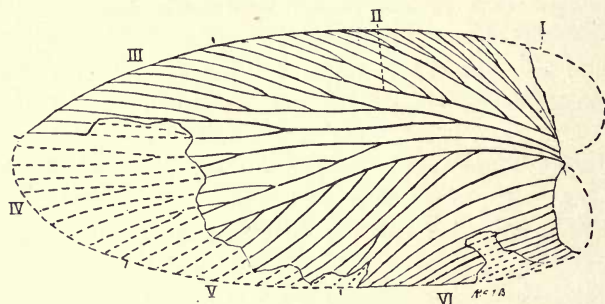


Fig. 33.—*Archimydris hastata*, Bolton; diagram of venation of left fore-wing, three times natural size.—Upper Coal Measures (Gellideg Level of the Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol. (nos. 24501, 24502). Lettering of veins.—I, costa; II, subcosta; III, radius; IV, median; V, cubitus; VI, anal.

The subcostal vein passes out obliquely from the point of attachment and reaches into the distal third of the wing. It gives off 9—10 very oblique branches, the basal three forking twice, the next two undivided, and the last branch but one forked. The subcostal area is broad basally, and terminates in an acute angle distally.

The actual origin of the principal veins is lost, and the radius appears at its origin therefore to be widely removed from the subcosta. It follows a parallel course to the origin of the first anterior branch, and afterwards diverges, so that it finally ends on the apex of the wing near the middle line. The first branch is important, forking three times in its course and ending in six divisions. The second branch forks only once.

The subcosta and radius together occupy a little less than half the whole wing-area. Dr. Pruvost supposes that a commissural branch unites the radial sector and the median in this species (1919, 'Mémoires pour servir à l'Explication de la Carte Géologique Détaillée de la France,' p. 151), but I cannot perceive this.

The median vein arises in actual contact with the stem of the radius, or is

united with it, rapidly diverging to the distal part of the inner margin. Four branches are given off on the outer side, the first forking before the broken edge of the wing is reached. The remaining three probably forked also on the missing part of the wing-apex. The subdivisions of the median occupy the inner half of the wing-apex, and the apex itself.

The regularity of arrangement of the minor veins is a marked feature of this wing, and lends colour to our supposition.

The cubitus gradually diverges from the median along the whole of its course. Ten branches are given off on the inner side, the first only forking.

The anal area is sharply marked off from the rest of the wing by a deep anal groove, the anal area being elevated and somewhat convex in outline. Ten to eleven anal veins can be distinguished, the marginal ones being very short and feeble.

The interstitial neuration consists of close, strong, transverse nervures so numerous as to give the wing-surface a finely corrugated appearance.

The tegmina were apparently of great strength, the unusual development of the transverse nervures adding to the rigidity, while the presence of an oblique ridge served to support and strengthen the radius, median and cubitus at their base, and a similar ridge gave support to the whole of the anal area.

Affinities.—In 1911 (*loc. cit.*) I gave reasons for regarding this species as an Archimylacrid, comparing it with *A. spectabilis*, Goldfuss, and *A. venusta*. More recently, Dr. Pruvost ('Ann. Soc. Géol. Nord,' vol. xli, p. 335, pl. ix, figs. 4—4 a, 1912) has expressed the opinion that it is so nearly like *A. belgica*, Handlirsch, and a specimen he has himself described from the roof of the Alfred Vein, Liévin, Northern France, as to be referable to that species. An examination of the figures published by Handlirsch and Pruvost does not support this view. *Archimylacris belgica* was founded by Handlirsch ('Mém. Mus. Roy. Hist. Nat. Belg.,' vol. iii, p. 12, pl. iv, figs. 17—18, 1906) on a wing in the Brussels Museum, from the Westphalian or Middle Upper Carboniferous of Jemappes, Belgium. It was afterwards transferred by him to a new genus, *Parellthoblatta* ('Die Fossilen Insekten,' p. 184, pl. xviii, fig. 54, 1906). This new genus is not accepted by Pruvost, who considers that it is founded chiefly on the pectinate character of the first branch of the radius. He therefore replaces the species in the genus *Archimylacris*, and refers his own specimen to the same genus and species. With this conclusion I cannot agree. Handlirsch's species is characterised not only by the pectinate character of the first branch of the radius, but (and much more important) by the presence of a meshwork of interstitial neuration between the radius, median and cubitus. This latter feature clearly separates not only the French specimen from Handlirsch's genus *Parellthoblatta*, and therefore from *P. belgica*, but the British specimen also; for in both the interstitial neuration consists wholly of a close series of straight cross-nervures, with not the slightest trace of the development of a network.

A. hastata is closely allied to the French species, but the divisions of the main veins are fewer and of a more simple nature. I see no reason to remove the British species from the genus *Archimylacris*, and would refer the French example also to the same genus. This view is now accepted by Pruvost (*loc. cit.*, p. 158).

Archimylacris woodwardi, Bolton. Plate VII, fig. 2; Text-figure 34.

1910. *Archimylacris (Etoblattina) woodwardi*, Bolton, Geol. Mag. [5], vol. vii, pp. 147—151, pl. xv, figs. 1—1 a.

Type.—A left tegmen or fore-wing, 18 mm. long and 10 mm. wide; collection of Mr. D. Davies, F.G.S.

Horizon and Locality.—Coal Measures (a ten-foot shale overlying the No. 2 Rhondda Seam, base of the Pennant Series); Clydach Vale, South Wales.

Specific Characters.—Wing short and broad. Apex well rounded and merging

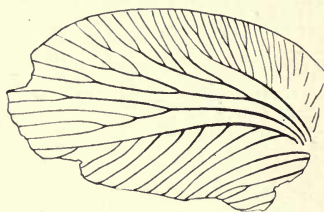


FIG. 34.—*Archimylacris woodwardi*, Bolton; diagram of wing-venation of left fore-wing, three times natural size.—Base of Pennant Series (roof of ten-foot shale overlying the No. 2 Rhondda Seam); Clydach Vale, South Wales. David Davies Collection.

into costal border. Anal area convex. Interstitial neuration of abundant stout cross-nervures, occasionally uniting laterally.

Description.—The tegmen, which is short, broad and strongly chitinous, lies with the convex dorsal surface uppermost. The well-rounded outer margin of the wing merges into the equally well-rounded apex. The inner margin is nearly straight, a slight hollowing only of the middle portion being shown. Notwithstanding its small size, the details of the wing are very clear, the veins and the interstitial neuration being well shown. The basal portions of the main veins are elevated above the surface, the rest of their length and also their divisions being sunk below the general level.

The subcostal vein is weak, and sunk along its whole course. It is widely separated from the costal margin, following a parallel course to beyond the middle of the wing, where it bends outward and joins the margin. The subcosta gives off a numerous series of forked and simple divisions to the costal margin.

The radius arises close to the subcosta and median, diverging from the former in the middle of its length, and approaching it again by the first of the four outer

branches which it gives off. The first two branches of the radius are forked, the rest undivided. The radius with its divisions occupies the distal third of the wing-margin. At the junction of the basal and middle thirds of the wing, the radius gives off a strong radial sector which diverges from it, giving off two outer branches, the first forking twice into four twigs. The radial sector occupies the outer half of the wing-apex.

The median curves regularly inwards along its whole course, reaching the inner end of the wing-apex, and giving off three outer branches, of which the first is forked. With its subdivisions it occupies a much less area than any other main vein.

The cubitus follows a course nearly parallel with the median, and gives off nine inward branches. With its subdivisions, it occupies almost the whole of the distal two-thirds of the inner margin.

The anal area is strongly convex, and crossed by at least five anal veins, the third being forked.

The interstitial neurulation is well developed in the neighbourhood of the subcosta, and consists of a close-set series of straight cross-nervures. These are in relief, and in places seem to unite laterally, and to cross the main veins.

Affinities.—The wing is typically Archimylacrid. At the time of its discovery in 1910 I was unable to show that it possessed a close relation to any known species, but more recently Dr. Pruvost has recorded a very similar example, *A. atrebatica*, Pruv., from the Coal Measures of Bruay, Northern France.

The presence of a well-defined radial sector is a Palæodictyopteroïd feature which most Blattoids have lost, and stamps the species as primitive. It is therefore interesting to find that Pruvost draws special attention to the fact that *A. atrebatica*, Pruv., is the oldest Archimylacrid of the Northern French Coal Measures, being found in the lower portion of the Formation of Bruay, over the vein Ernestine at Lens, in a shale containing seeds and drifted plant-remains.

Archimylacris incisa, sp. nov. Plate VII, fig. 3.

Type.—Pronotum, mesonotum, and the basal portions of the tegmina in an ironstone nodule; British Museum (Johnson Collection, no. I. 15900).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Specific Characters.—Wing robust. Principal veins widely spaced. Interstitial neurulation of stout cross-nervures, which unite in a meshwork in the wide areas.

Description.—These Blattoid remains are 21 mm. long. The pronotum lies with its underside uppermost on that portion of the nodule which also bears the impressions of the under surfaces of the tegmina, while the impression of the underside of the pronotum and the fragments of the tegmina upside down occur

on the other half. The hinder margin of the pronotum is still hidden in the matrix, and the impressions of the under-surfaces of the wings would need to be destroyed to expose it.

The pronotum is semicircular in outline, so far as can be determined. The inner surface is marked out into two lateral areas which join in front of, and behind, the central area, the latter being hollow, probably to lodge the head of the insect during life. The central hollow of the pronotum is crossed in front and behind by close-set parallel wrinkles, while a suture-like crack traverses the whole structure in the middle line. Posteriorly to the central hollow, the lateral halves have separated and become wrinkled up against each other.

The condition of the pronotum shows that it was convex, the central hollow of the inner surface marking off an area which was more convex than the sides, and separated from them by grooves which bent round and joined behind the central more elevated area. The central area is thinner than the sides and infolded.

Lying behind, and partially overhung by the hind border of the pronotum, is a heart-shaped structure, irregularly indented, owing its superficial appearance to the overlap of the anal areas of the wings on it. On one side of this structure can be seen what appears to be part of a stout segment, having a thickened anterior border, and a convex surface bearing a few low tubercles. The central indented structure occupies the position of the mesonotum, and the lateral stouter segment may be a part of it, or of the metanotum which has been pushed forward.

The base of the left tegmen is in actual articulation with what I suppose to be the mesonotum. As the tegmina lie with their under surface uppermost, the impressions on the opposite half of the nodule are also of the same surface.

The fragment of the left tegmen is largest, and in the best condition, but not more than a third of it is present. The tissue is thickly chitinous, much more so than that of the pronotum.

The costal margin is convex, and the costal area strap-shaped and wide. Seen from the underside it appears smooth, a few diagonal wrinkles alone crossing the surface. We may therefore infer that the divisions of the subcosta are weakly incised on the upper surface.

The subcostal vein is more convex in direction than the margin, the costal area being widest at the base.

The radius arises close to the subcosta, and gradually diverges from it. It shows no divisions in the basal portions preserved.

The median vein arises even closer to the radius than does the latter to the subcosta, and bends inwards in a convex curve for some distance, afterwards flattening and becoming parallel with the radius.

The cubitus arises closer to the anal furrow than to the median, but bends outwards in a bold sweep away from it, becoming almost parallel with the median. It gives off three inward branches in the part preserved, the first low down near

the base, and the remaining two at wide intervals further out. The course of the main stem is such as to indicate that it reached the distal portion of the inner margin, so that the wing-apex was wholly occupied by the divisions of the radius and the median.

The anal veins seen are five in number, the first forking twice and the rest single. They probably occupied the proximal third of the inner wing-margin.

The articulation of the tegmen to the mesonotum seems to have been strengthened by the formation of three ridges, two formed by the deepening of the bases of the subcosta and radius, and a third by a similar thickening just inside the anal furrow, which in this specimen coincides with the line of the first branch of the cubitus.

The basal part of the subcostal area shows a deep hollow; this feature is seen in several of the British Blattoids, and favours the assumption that while the point of attachment lay immediately behind, the frontal part of the mesonotum developed an area which served as a fulcrum for the tegmina.

The right tegmen is represented only by the base of the costal border and subcosta, short portions of the radius, median, a part of the cubitus with two proximal branches, and the inner anal vein dividing into three.

The interstitial neurulation consists of strong cross-nervures, frequently uniting laterally, and on the broader areas forming a slight open meshwork.

Affinities.—Fragmentary though the wing is, it yet shows many of the features of *A. venusta*, Scd., having the same wide costal area, the same relation of subcosta, radius and median so far as these can be traced, and the cubitus beginning to branch low down before the radius and median show any trace of branching. The interstitial neurulation in both consists of straight cross-nervures occasionally uniting laterally.

This wing is more robust than that of *A. venusta*, Scd., and the anal veins are more oblique in direction. The whole of the main veins and those of the anal area are more widely spaced. In its robust character the wing approaches *A. acadica*, Scd., but in that species the interstitial neurulation does not unite laterally.

Archimylacris (Schizoblatta) obovata, Bolton. Plate VII, fig. 4; Text-figure 35.

1911. *Archimylacris (Schizoblatta) obovata*, Bolton, Quart. Journ. Geol. Soc., vol. lxxvii, p. 157, pl. vii, figs. 4—6.

Type.—The distal two-thirds of a left tegmen, having a length of 23 mm. and a greatest breadth of 10 mm.; Museum of Practical Geology, Jermyn Street (nos. 24506 and 24507).

Horizon and Locality.—Base of the Upper Coal Measures (Gwernau Level of the Mynyddiswyn Vein); Maes-y-cwmmwr, Monmouthshire.

Specific Characters.—Costal border moderately convex, and passing into a

There is no trace of the anal portion of the wing, or of the remainder of the cubitus.

The wing is thick, coriaceous in texture, and convex dorsally. The whole surface is covered by a dense series of irregular oblique wrinkles. In some places a close-set series starts out from the sides of a vein, and dies out in the interspace. In other places sets of wrinkles are interrupted by smooth interspaces, this arrangement occurring at haphazard. There are a few cases in which the wrinkles unite.

Affinities.—There can be no doubt as to this specimen representing an Archimylacrid. Dr. Handlirsch, who makes *Archimylacris* the type of a family, Archimylacridæ ('Proc. U.S. National Museum,' vol. xxix, p. 722, 1906), has also founded a new genus, *Schizoblatta*, and with the type-species of this genus the specimen here described is in close agreement.

The points to which I attach importance are the following: In both, the subcostal area extends for a short distance beyond the middle line, the veins in each case passing out obliquely to the margin. A very wide interval separates the stem of the subcosta from that of the radius in the middle of their length, and this area is narrowed distally in each case by the approach of the marginal veins. The radius is a large and much branched vein, and separates into two main divisions, which fork at the same level and reach the apical point of the wing—in this specimen just beyond it. The median is relatively small, while the cubitus has few branches, passing obliquely out, like those of the subcosta, to the margin.

The anal area in the type, *Schizoblatta alutacea*, is long, attaining nearly half the length of the wing. In the specimen here described this part is missing, as is also a part of the cubitus. The missing portion of the inner margin extends beyond the middle of its length, and knowing how frequently the anal vein determines the line of fracture, this extended broken area becomes significant.

Dr. Handlirsch's definition of the genus *Schizoblatta* is as follows: "Front wing elliptical, about two and two-fifth times as long as broad. Costal area extending about three-fifths the length of the wing, with about nine or ten normal veins; not expanded at the base. Radius divided into two principal stems, the superior of which separates into six branches and the inferior into eight, the majority of the latter ending in the apical border. The median likewise divides into two main stems, the anterior of which forms five branches, and the posterior four, all of which fuse in the apical margin. The eight branches of the gently vaulted cubitus take up the entire inner border. The anal area attains nearly half the length of the wing. Cross-veins area not to be distinguished, but instead there is a fine-grained leathery structure" (*loc. cit.*).

If the genus is to be maintained apart from that of *Archimylacris*, I would base the characters on the obliquity of the marginal veins of the subcosta and cubitus,

the presence of a wide interval between the former and the radius, and the wide area occupied by the latter.

The division of the radius into two unequal branches, with its symmetrical double bifurcation, is also, I venture to think, a feature of primary importance.

In the wide divergence of the radius and median, this species agrees with Scudder's genus *Spiloblattina*; but in this case the veins do not converge again to enclose an elongated or oval area.

Archimylacris, sp. indet. Plate VII, fig. 5.

1911. *Archimylacris*, sp. indet., Bolton, Quart. Journ. Geol. Soc., vol. lxxvii, p. 163, pl. x, fig. 3.

Type.—A fragmentary wing, lacking the apex and the base; Museum of Practical Geology, Jermyn Street (no. 24503).

Horizon and Locality.—Base of Upper Coal Measures (Gellideg Level of the Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire.

Description.—The specimen is much too fragmentary for any attempt at specific determination. A portion of the distal margin is present, with three branches of the subcosta. These are succeeded by eight straight veins, two at least forking, which belong to the radius and median series. These are followed by an equal number of veins partially hidden by the surface of the integument, which is much wrinkled over this area. These, I assume, are parts of the cubitus vein. The wrinkling of the integument over the cubital area is very marked.

The special interest of this wing-fragment is in its association with portions of a leaf of *Cordaites*. Scudder and others have commented on the general association of the wings of Blattoids with leaves of *Cordaites*, but have not, so far as I am aware, drawn attention to a feature which is well shown by this leaf, namely, pits on its surface. I have repeatedly found such depressions on the leaves of *Cordaites* in the Lancashire Coalfield, and in many cases seen the hollows occupied by the shells of *Spirorbis pusillus*. The shallow pits on the *Cordaites*-leaf associated with this fragmentary wing show faint traces of a spiral, similar to the impression of *Spirorbis*, and such shells were, I think, once attached to it. While the Carboniferous Blattoids may have been wholly phytophagous, we are led by our knowledge of the living Blattids, especially by the common cockroach (*Periplaneta orientalis*), to assume the contrary, and to regard them as more likely to have been omnivorous, in which case the association of Blattoid remains with the leaves of *Cordaites* bearing the sedentary *Spirorbis* is easily understood. The association also lends support to the belief that the Blattoids were semi-aquatic in habit, or lived in marshes and swamps in which decayed vegetation formed a home for *Spirorbis*.

Archimylacris, sp. indet. Plate VII, fig. 6.

1911. *Archimylacris*, sp. indet., Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 152, pl. vii, fig. 2.

Type.—Impression of basal portion of left tegmen; Museum of Practical Geology, Jermyn Street (no. 24508).

Horizon and Locality.—Base of Upper Coal Measures (Mynyddislwyn Vein, Gellideg Level); near Maes-y-cwmmer, Monmouthshire.

Genus **PHYLOBLATTA**, Handlirsch.

1906. *Phyloblatta*, Handlirsch, Bull. U.S. Nat. Mus., vol. xxix, p. 738.

Generic Characters.—Tegmina elliptical, two-and-a-quarter to two-and-a-half times as long as wide; costal area strap-shaped, rarely wide, and extending usually to three-fifths or two-thirds the length of the wing; not expanded basally. Radius with numerous branches, all of which reach the outer margin. Median with outer branches only, reaching wing-apex. Cubitus large, much branched, and occupying distal two-thirds of inner margin. Anal area large with numerous veins. Interstitial neuration rugose leathery or much cross-wrinkled.

Phyloblatta sulcata (Bolton). Plate VIII, fig. 1; Text-figure 36.

1911. *Gerablattina* (*Aphthoroblattina*) *sulcata*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 165, pl. viii, figs. 1—3.

Type.—Greater part of tegmen and its counterpart impression showing the under surface only; Museum of Practical Geology, Jermyn Street (nos. 24504 and 24505).

Horizon and Locality.—Base of the Upper Coal Measures (Gwernau Level of the Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire.

Specific Characters.—Costal area broad; subcosta strap-shaped, and extending far out. Radius with six branches, occupying outer half of wing-apex. Median with few divisions and occupying a small area of the wing. Cubitus united with median at the base. Anal furrow well developed. Anal veins 5—8.

Description.—The specimen comprises the greater part of a right tegmen, showing the under surface, the counterpart impression being on a second piece of black shale. An irregular narrow fringe of the wing-membrane has been lost along the outer and inner margins, and the inner half of the wing-apex is also missing. The length of the fragment is 35 mm., and the greatest width 16 mm., the perfect wing being probably about 45 mm. long, and 22—23 mm. wide. If this estimate is correct, the wing is short. Tegmina are usually at least two-and-a-half

times as long as wide. The structure is well preserved, and the principal veins and their subdivisions are in relief.

The costal margin is thickened, strongly convex, and well rounded at the base. The costal area is unusually broad and strap-shaped, extending over two-thirds of the costal margin. The basal portion of the costal area is smooth, and not crossed by branches of the subcosta.

The subcosta is thin, elevated basally, and somewhat crenulated, doubtless owing to post-mortem change or pressure. The subcosta is parallel with the costal margin over more than one-half the length of the wing, and gives off six oblique branches to the margin. Three of these branches are forked.

The radius passes out to the apex of the wing, giving off six outer branches, the first forking once, and the second twice before reaching the margin. The

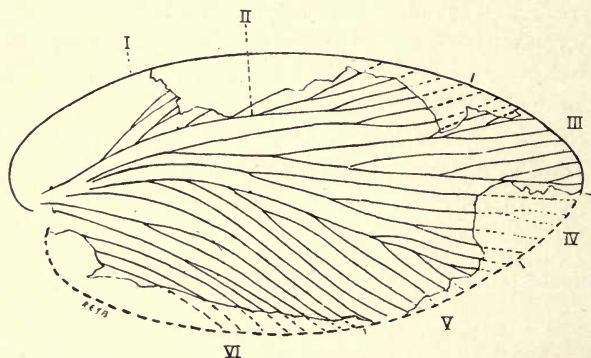


FIG. 36.—*Phylloblatta sulcata* (Bolton); diagram of the venation, and restored outline of fore-wing, two-and-a-half times natural size.—Upper Coal Measures (Gwernau Level of the Mynyddislwyn Vein); near Maes-y-cwmmwr, Monmouthshire. Mus. Pract. Geol. (nos. 24504, 24505). Numbering of veins as in Text-figure 33, p. 104.

remaining branches are undivided. The radius and subcosta together occupy a little less than half the total wing-area.

The median vein is convex outwards in its basal half, and then bends inwards to the junction of the inner and apical margins. It gives off three long, outward, undivided branches, all of which are parallel with the main stem of the radius. Basally, the median curves sharply inwards and unites with the cubitus, the two veins having a very short common stem.

The cubitus is the largest and most important vein in the wing, although but faintly outlined at the base, where its union with the median is nevertheless quite clear. It gives off seven inwardly directed branches, the third only forking. On its outward side two branches are given off.

The anal furrow is represented by a strong ridge, and is therefore a well-marked groove on the dorsal surface of the wing. The anal area is large, extending at least one-third the length of the inner margin, and crossed by five

anal veins, the first and second only being forked. The whole of the anal area is not shown, and 3—4 veins may be missing.

The interstitial neuration consists of a close series of transverse nervures or wrinkles, it is impossible to say which. They are best seen in the anal and cubital areas.

Affinities.—The union of the stems of the median and cubitus veins, the occupation of the greater part of the inner half of the wing by the median, whose branches take up the whole of the inner margin outside the anal area, and the strong parallelism of the branches of the principal veins, are well-marked features which in the main agree most, I think, with *Phylloblatta*. Its resemblance to *Gerablattina* is also marked, and it is well to remember that Handlirsch has referred several species originally placed in the latter genus to *Phylloblatta*. This question of the generic relationship is a good example of the difficulty of allocating species to genera whose characters are not wholly known.

Phylloblatta transversalis, Bolton. Plate VIII, fig. 2; Text-figure 37.

1917. *Phylloblatta transversalis*, Bolton, Proc. Birmingham Nat. Hist. Phil. Soc., vol. xiv, pp. 100—103, pl. vii, figs. 1, 2.

Type.—Remains of two Blattoids, consisting of the tegmina, two pronota, and portions of the hind-wings, in a split nodule of ironstone, 60 mm. long, and 45 mm. broad; Geological Museum, University of Birmingham.

Horizon and Locality.—Coal Measures; Staffordshire.

The nodules were collected by Dr. Blake and agree in all respects with those found at Tipton and Coseley, Staffordshire, in the binds between the "Brooch" and "Thick" coals of the Middle Coal Measures.

Specific Characters.—Radius relatively simple with five branches, radial sector large and evenly forked; median vein small, with three outer branches; cubitus vein long with seven inward branches; anal area small with few anal veins.

Description.—The remains of three insects are shown on the split surfaces of two small ironstone nodules. The larger nodule contains the remains of two Blattoid tegmina, two pronota, and fragments of hind-wings. One tegmen is almost complete, while of the other more than half is shown, the distal end having been lost in splitting the nodule.

The tegmina lie with the under surfaces uppermost, the impression of the underside being preserved on the larger portion of the nodule. As both are from the left side, it follows that they belong to two insects—a conclusion confirmed by the presence of a pronotum in close association with each. In the case of the more nearly complete tegmen, the pronotum lies a little apart, and upside down, like the tegmen, while the pronotum of the more incomplete wing lies on the basal

portion of the tegmen itself, and has the dorsal surface uppermost. Traces of hind-wings are present, lying on a slightly lower plane than the tegmina, and showing only the underside.

As the two tegmina are specifically identical, the more nearly complete example has been taken as the type and is here described in detail.

The tegmen has a length of 32 mm., and, as a small part of the apex is missing, its total length must have been about 35 mm. The width is uniform over the basal half of the wing, and averages 11.5 mm.

The costal margin forms a strong convex curve, in this respect contrasting with the inner margin, which is nearly straight. The wing-apex is directed backwards owing to the great convexity of the costal margin. The whole wing has a broad semilunate appearance.

The subcosta is a feeble vein, not easily discernible; its outwardly-directed twigs pass out obliquely, and are twice or thrice forked. Like the main stem, they are faintly impressed, and cannot be traced up to the costal margin. Eight twigs can be determined. The subcostal area is strap-shaped, and extends beyond the middle of the wing.

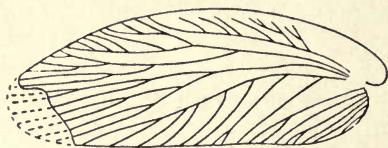


FIG. 37.—*Phylloblatta transversalis*, Bolton; diagram of venation of left fore-wing of type-specimen, twice natural size.—Middle Coal Measures; Staffordshire. Geol. Mus. Univ. Birmingham.

The radius is a strong vein, and shows an inner sub-division which has all the characters of a radial sector. Basally, it seems joined to the median, but it is an apparent junction only, the wing-base being pressed in upon itself, and bringing the two close to one another. After giving off the inner (radial sector) branch, the radius gives off five outer branches which reach the distal third of the outer margin. The first of these branches seems to break up into three twigs, but the structure of the wing is not clear at this point. The radial sector, which arises in the basal half of the wing, forks at the distal third into two equal branches, the outer forking twice into four divisions, and the inner forking once. The radius and radial sector occupy the whole of the outer half of the wing-apex.

The median vein diverges from the radius along its whole course, and reaches the distal end of the inner margin, giving off three outer branches in the distal half of the wing. These pass straight to the apex, the first forking twice, and the second once, the third remaining undivided to the broken edge of the wing. The branches of the median occupy the whole of the inner half of the wing-apex.

The cubitus remains above the middle line of the wing in the basal third, curving inwards and flattening in the outer two-thirds of the wing, and giving off seven inward branches, the second alone forking low down near the margin.

The anal area is small, and crossed by six oblique anal veins, the first and third of which fork.

The interstitial neuration consists of a close-set series of straight cross-nervures which unite laterally as they cross the wider areas.

The pronotum in close apposition with this wing has its inner surface uppermost. This shows a central shallow concave area, bounded by two lateral ridges, which die away as they approach the hinder border. The general outline is broadly circular.

The second tegmen is much less exposed than the first, and has its apex buried under the second pronotum. So far as its structure can be determined, it agrees with the wing already described.

The second pronotum has been crushed, the anterior border being turned round upon the base of the wing, and partly broken away. The posterior margin is almost straight, and that of the anterior well rounded.

Traces of two hind-wings are shown, one a little in advance of the more nearly complete wing, and partly underlying it, and the other underlying the costal and radial areas of the second incomplete wing. The first hind-wing shows a portion of the distal extremity, with a series of incomplete veins, probably belonging to the radius, median, and cubitus; the remains of the second hind-wing probably consist of the distal radial twigs only.

Affinities.—The distinguishing features of the tegmina are essentially those of *Phyloblatta*, unless we except the interstitial neuration. This is composed of straight cross-nervures, which unite laterally across the wide areas between the main stems of the radius, median, and cubitus, but not producing anywhere a meshwork such as is usually seen in the *Phyloblattids*.

Handlirsch doubts the presence of a cross-neuration in the genus *Phyloblatta* ('Proc. U.S. National Museum,' vol. xxix, p. 731, 1906), but there seems no reason why it should not be present in the more archaic members of the genus, as they all have an Archimylacrid ancestry, in which a cross-neuration is a dominant feature.

The species is closely allied to a form figured as *Gerablattina* sp. by Brongniart ('Insectes Fossiles des Temps Primaires,' pl. xlvi, fig. 7, 1893), and repeated by Handlirsch ('Die Fossilen Insekten,' pl. xxx, fig. 35, p. 295, 1906) under the name of *Blattoidea*, sp. Handlirsch regards Brongniart's specimen as belonging either to the *Spiloblattinidae* or to the *Archimylacridae*. Unfortunately the interstitial neuration is not shown. If, as in these specimens, Brongniart's species possesses a cross-neuration, or one in which the nervures unite laterally, it must be referred to *Phyloblatta*.

(*Archimylacridæ*) *kirkbyi* (Woodward). Plate VIII, fig. 3.

1887. *Lithomylacris kirkbyi*, Woodward, Geol. Mag. [3], vol. iv, p. 55, pl. ii, figs. 4*a*—4*b*.

1887. ? *Hermatoblattina kirkbyi*, Scudder, Proc. Bost. Soc. Nat. Hist., vol. xxiii, p. 357.

1906. (*Archimylacridæ*) *kirkbyi*, Handlirsch, Die Fossilen Insekten, p. 238, pl. xxiv, fig. 37.

Type.—Left wing (tegmen); formerly in the collection of the late Mr. James Kirkby.

Horizon and Locality.—Upper Coal Measures (bed No. 33); near Meithil, coast of Fifeshire.

Description.—Our knowledge of this wing depends on the description and figures published by Dr. H. Woodward. His description is as follows: "Outline of wing pointed-ovate, slightly flattened on its superior border; length of wing 15 mm., breadth 8 mm. The 'mediastinal' [subcostal] vein occupies rather more than a fourth of the entire area of the wing; it extends to about two-thirds of the length, where it unites with the superior margin of the wing; it branches six times; one of these branches has three forks. The 'scapular' [radius] vein extends nearly to the extremity of the wing; it remains single for over one-fourth of its length, and then branches into three veins, the middle one of which is again forked. The 'externo-median' [median] vein continues parallel to the scapular vein for a slightly longer distance before it branches at the extremity of the wing into three inferior veins, two of which are again forked. The 'interno-median' [cubitus] vein occupies about one-fourth the entire area of the wing; it gives off three almost equidistant branches, none of which appear to be forked. The anal vein is nearly straight, and has three other almost parallel oblique simple veins occupying the anal area."

Affinities.—Neither Woodward's figures nor the later modified drawing published by Handlirsch are very helpful in enabling us to identify the genus. Handlirsch has reversed the figure given by Woodward, and shows three veins which may belong to the subcosta, a radius with three forward branches, and a well-divided median ending on the wing-apex in nine outer branches. Woodward's "mediastinal" becomes the cubitus, and no anal veins are shown. This seems a more reasonable interpretation of the wing.

Woodward's comparison of the wing with *Lithomylacris pittstonianum*, Sed., is unfortunate, as in that species the radius is a large, much-branched vein, occupying nearly half the outer margin, while the radius (scapular) in *A. kirkbyi*, Woodw., has three divisions only as shown by him, although it is a more branched structure when the figure is reversed and the veins reconsidered, as by Handlirsch.

In the absence of the type-specimen, it is not possible to do more than refer the species to the family Archimylacridæ.

BLATTOIDS INCERTÆ SEDIS.

Remains of Blattoids have been found at four horizons and in four localities in the Kent Coalfield. They were obtained from small cores, the edges of which had cut through the wings, and rendered them so fragmentary as to be useless for the determination of genera or species. They serve, however, to indicate that the Kent Coal Measures may eventually prove to be as rich in fossil insect-remains as the Coal Measures of the Pas-de-Calais. The depths of the cores given with the original description of these fossils were found afterwards to have been reckoned from a private datum, while the depths now given have been corrected to Ordnance datum.

Phylloblatta (?), sp. Plate VIII, fig. 4.

1912. *Phylloblatta* (?), sp., Bolton, Quart. Journ. Geol. Soc., vol. lxxviii, p. 321, pl. xxxiii, figs. 3, 4, 5.

1915. *Phylloblatta* (?), sp., Bolton, Trans. Inst. Min. Eng., vol. xlix, p. 45.

Specimen.—Impression of a Blattoid wing, 5 mm. long and 2.5 mm. wide; Museum of the Kent Coal Concessions Company, Dover.

The impression is that of the middle part of the margin of a tegmen. This may be a part of the outer margin, as I formerly supposed, but I now think it more likely to belong to the inner margin, and to show branches of the median and cubitus veins.

Horizon and Locality.—Shales at a depth of 1967 ft. in the Maydensole boring, Kent Coalfield.

Phylloblatta (?), sp.

1912. *Phylloblatta* (?), sp., Bolton, Quart. Journ. Geol. Soc., vol. lxxviii, p. 321, pl. xxxiii, figs. 8, 9.

1915. *Phylloblatta* (?), sp., Bolton, Trans. Inst. Min. Eng., vol. xlix, p. 45.

Specimen.—Impression of part of a Blattoid wing, 6 mm. long and 3 mm. wide; Museum of the Kent Coal Concessions Company, Dover.

The fragment appears to belong to the proximal part of the wing, and shows a long vein giving off six branches.

Lying more inward are the remains of a short forked vein.

Horizon and Locality.—Shales at a depth of 954 feet in the Ripple boring, Kent Coalfield.

BLATTOID WING-FRAGMENT. Plate VIII, fig. 5.

1912. "Blattoid," Bolton, Quart. Journ. Geol. Soc., vol. lxxviii, p. 321, pl. xxxiii, figs. 6, 7.

1915. "Blattoid," Bolton, Trans. Inst. Min. Eng., vol. xlix, p. 45.

Specimen.—Impression of a wing-fragment 3 mm. long and 2.25 mm. wide; Museum of the Kent Coal Concessions Company, Dover.

The fragment shows a little of a well-curved margin and three veins, one with a small fork on the wing-margin. The curvature indicates that the fragment belongs to the apical end of the wing.

Horizon and Locality.—Black shale at a depth of 2180 feet in the Barfreston boring, Kent Coalfield.

BLATTOID WING-FRAGMENT. Plate VIII, fig. 6.

1915. "Blattoid," Bolton, Trans. Inst. Min. Eng., vol. xlix, pp. 45; 46, pl. ix, fig. 24.

Specimen.—Distal portion of a tegmen, including the whole of the wing-apex; Museum of the Kent Coal Concessions Company, Dover.

Portions of the subcosta, radius, and median veins can be determined. The subcosta is represented by a little of the main stem which sends off four simple branches to the outer margin. The radius divides low down into two branches, the outer dividing again into two nearly equal twigs, which pass out to the outer margin of the wing. The inner branch divides into four twigs, all reaching the apical margin. The cubitus is represented by a long vein, giving off a series of eight to nine inward branches.

Horizon and Locality.—Shales at a depth of 2424 feet in the Stonehall boring, Kent Coalfield.

Family MYLACRIDÆ, Scudder.

1879. Scudder, Mem. Bost. Soc. Nat. Hist., vol. iii, pt. 1, no. 3, p. 40.

1906. Handlirsch, Die Fossilen Insekten, p. 258.

Fore-wings variable in shape, but generally broad and short, nearly always widest at the base. Costal area more or less triangular. Subcosta with branches arising in a radial manner. Radius sending numerous branches outwardly, or dividing into two widely dividing branches. The median either gives off its branches serially, or forms two compound main branches. Cubitus with a variable number of inward branches. Anal area large, with the anal veins usually ending on the inner margin (Handlirsch).

Scudder established this family for a numerous series of North American Blattoids, all of which are characterised by the subcostal area being widened out basally, and the subcostal vein and its branches reduced from the strap-shaped form seen in Archimylacrids to a shorter structure, in which the branches arise mainly from the root of the vein, and radiate in fan-fashion into the subcostal area.

The humeral portion of the subcostal area is usually smooth, and destitute of subcostal branches, or where these are present, they are short and do not reach the margin. Owing to the enlargement of the subcostal area, the point of attachment

of the wing becomes central, instead of being in front of the wing-axis as in the Archimylacridæ. The principal veins and their branches show a greater tendency to pass straight outwards to the wing-margin than in the Archimylacridæ, while the pronotum has become broader and shorter, and assumes more of a reniform appearance.

The wing-surface is leathery and coriaceous, and often cross-wrinkled. Pruvost states that the interstitial neuration is composed of a fine network of nervures, which is more correct, the thickened wrinkled condition being a later development. The body is broad and flat.

Handlirsch regards the Mylacridæ as an early, extremely developed, lateral branch of the Blattoid series, and thus still retaining rather primitive characters, best seen in the median vein. Handlirsch adds (1906, 'Proc. U.S. Nat. Mus.,' vol. xxix, p. 766): "Perhaps they owe their origin to an adaptation to their environment, for it is remarkable how similar many of them are to certain leaves of ferns, with which they are generally found (a fact to which Scudder had already drawn attention). Probably they lived under deciduous fern-fronds, and by their similarity to the pinnæ were protected from their enemies."

Pruvost (1920) considers that the Mylacridæ may constitute a well individualised phyletic series which sprang late from the Archimylacrid stock. He divides the family Mylacridæ into two divisions, Hemimylacridian and Mylacridian, the former, as typified in *Phylomyllacris* and *Hemimylacris*, being really intermediate forms lying between the true Archimylacrids and the true Mylacrids (Mylacridians), and more nearly descended from the first. Pruvost also points out that Handlirsch has placed *Apophthegma* (the *Hemimylacris* of Saxony) with the Archimylacridæ, and the American members of the *Hemimylacris* among the Mylacridæ. He is somewhat uncertain whether to place the Hemimylacridians with the Archimylacridæ or with the Mylacridæ, but decides in favour of the latter, suggesting that both the Hemimylacridians and the Mylacridians are of polyphyletic origin.

Genus **HEMIMYLACRIS**, Handlirsch.

1906. *Hemimylacris*, Handlirsch, Proc. U.S. Nat. Mus., vol. xxix, p. 767.

Generic Characters.—Wings twice as long as wide. Costal area broad, in one species almost triangular, in another somewhat strap-shaped. Radius with four outer branches, the first dividing into two or three twigs. Median with three branches directed inwards. Cubitus with 4—5 branches which do not occupy the whole of the free inner margin. Anal area two-fifths the length of the wing, and more than twice as long as wide.

Handlirsch remarks that this genus may be classed almost as well with the Archimylacridæ as with the Mylacridæ, thus agreeing with Pruvost.

Hemimylacris obtusa, Bolton. Plate VIII, fig. 7; Text-figure 38.

1911. *Hemimylacris obtusa*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 154, pl. x, figs. 4, 5.

Type.—A stout right tegmen, lying on a surface of fireclay full of Stigmarian rootlets, and distorted by pressure; Museum of Practical Geology, Jermyn Street (no. 24510).

Horizon and Locality.—Upper Coal Measures (Four-foot Seam of Swansea); Gladys Colliery, one mile east-south-east of Penller-gaer Church, Glam.

Specific Characters.—Costal margin convex; subcostal vein dividing by repeated forking into five twigs; costal area triangular. Radius with a radial sector, the latter much divided. Median with a few forked inward branches. Cubitus large, with four branches, the second twice forked. Anal area wide, and crossed by numerous veins, the first giving off a simple branch, and then dividing twice by equal forking. Inner margin almost straight.

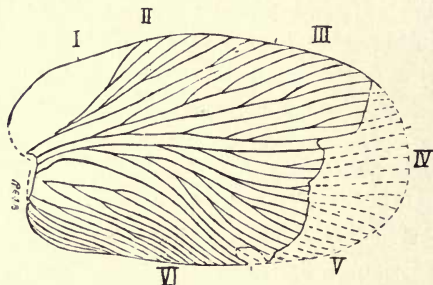


FIG. 38.—*Hemimylacris obtusa*, Bolton; diagram of right fore-wing with apex restored, three times natural size.—Upper Coal Measures (four-foot Seam of Swansea); Gladys Colliery, near Penller-gaer Church, Glamorganshire. Mus. Pract. Geol. (no. 24510). Numbering of veins as in Text-figure 33, p. 104.

Description.—A short rounded right tegmen, 23 mm. long and 14 mm. wide, broken across the basal third along the anal furrow, and the apex missing.

The subcostal area is broadly triangular, the subcostal vein sunken, and passing out obliquely, giving off a basal branch which forks into two equal twigs, the most distal twig forking again. A single undivided branch is given off near the end of the subcosta.

The radius gives off a strong radial sector, and afterwards sends outwardly three simple branches. The radial sector sends four branches to the margin, the first forking twice, and the fourth once, the second and third being simple.

The median vein appears to give off the stem of the cubitus near its base, but this appearance is probably due to the crumpling of the tegmen. The first of the three inward branches of the median arises further out than any of the divisions of the radius or cubitus. The first branch divides into three twigs, and the second forks on the broken edge of the wing. All the branches pass straight out towards the wing-apex.

The cubitus is convex in its basal half, and straightens out distally, giving off four inward branches, the second dividing into three, and the fourth forking. The divisions of the cubitus occupy the distal half of the inner margin.

The anal area is large, and marked off from the rest of the wing by a deep anal furrow. The first anal vein breaks up into five divisions, by a triple forking, and the second forks twice. The third anal vein forks near its base, and the remaining 3—4 veins appear simple. The anal veins end on the margin in at least fourteen twigs.

The interstitial neuration cannot be determined.

Affinities.—The mode of branching of the subcostal vein, the presence of a decided radial sector and the character of the first anal vein, are features which would justify the inclusion of this species in the genus *Soomyllacris*, were it not for the fact that the median is not divided into two equal branches. There is a close correspondence between this species and *H. ramificata*, Handl., and I therefore retain it in the genus *Hemimylacris*, although, as I have stated elsewhere, I am inclined to merge the two genera into one, as marking a transitional group between the Archimylacridæ and the Mylacridæ.

Hemimylacris convexa, Bolton. Plate VIII, fig. 8.

1911. *Hemimylacris convexa*, Bolton, Quart. Journ. Geol. Soc., vol. lxxvii, p. 156, pl. vii, fig. 3.

Type.—Proximal half of a tegmen lying on an irregular surface of black shale; Museum of Practical Geology, Jermyn Street (no. 24512).

Horizon and Locality.—Pennant Series (Shales associated with the Graigola Seam); Clydach Merthyr Colliery, Clydach Valley (Swansea Vale), Glam.

Specific Characters.—Costal area triangular. Radius with a well-defined radial sector, the two occupying most of the outer margin and the outer half of the wing-apex. Median small. Cubitus arcuated and ending on the middle of the inner margin, and outer third of the apex. Anal veins few.

Description.—Only the proximal half of the tegmen is shown, and this does not exceed 10 mm. in length. The subcostal area is much crushed and broken, and but two branches of the subcostal vein can be seen on it.

The radius arises in the middle of the base, and at once divides, evidently giving off a radial sector. The radius shows two marginal veins, while the radial sector sends off a long branch towards the wing-apex, the branch forking near the broken edge of the wing.

The median vein is represented by a portion of the main stem, which forks twice.

The cubitus has an arcuated stem bifurcating twice into four branches. Three anal veins can be distinguished.

Affinities.—The fragmentary and crumpled condition of this wing makes its elucidation difficult and unsatisfactory. The chief features distinguishable are the almost equal costal and anal areas, the presence of a radial sector, and the origin of several anal veins arising from one stem. Few though these characters be, they are sufficient to refer the specimen to the Mylacridæ, and to the genus *Hemimylacris*.

Genus **PHYLOMYLACRIS**, Pruvost.

1919. *Phylomylacris*, Pruvost, Faune Continent. Terr. Houill. N. France (Mém. Explic. Carte Géol. France), p. 199.

Generic Characters.—Tegmina semi-ovate, with rounded apex. Surface coriaceous, with a fine close meshwork of interstitial nervures giving a shagreen-like appearance. Wing-attachment in middle of wing. Costal area triangular. Subcostal branching, partly pectinated and partly radial, extending beyond the middle of the wing. Radius well developed. Median with numerous branches. Cubitus large and well branched. Anal area large, convex, and crossed by numerous anal veins.

Pruvost has formed this genus to include certain Blattoids found in recent years at Lens and Liévin in northern France. They possess a superficial resemblance to the type-species of *Necymylacris*, *N. heros*, Scd., but their differences are nevertheless so marked as to justify the formation of a new genus. Pruvost in the work in question placed Goldenberg's *Blattidium mantidioides* in the genus *Archæotiphe*, having at the time only the original drawings of Kirkby to rely on. After borrowing the type-specimen, I came to the conclusion that Goldenberg's species must be referred to a new genus, in which I also placed *Necymylacris villeti*, Pruv., *N. lafittei*, Pruv., and *N. godoni*, Pruv. To this new genus I proposed to attach the name of my French friend, Dr. P. Pruvost, and intimated my intention to him, at the same time sending my manuscript. I received a reply and the proof-sheets of his new work, in which it appeared that he also had recognised that the three species previously referred to *Necymylacris* must be placed in a new genus, to which he had already given the name of *Phylomylacris*. Our conclusions were identical as to the generic value of his species, and as his work antedates my own, I am unable to attach his name to the new genus, but must adopt the generic name of *Phylomylacris* for the British species.

Had Dr. Pruvost received my photographs and drawings earlier, he would not have referred *B. mantidioides* to the genus *Archæotiphe*, but to *Phylomylacris*, as he based the characters of the latter on the same details of structure as I had determined for the genus in which *B. mantidioides* should be placed. The fact that we arrived at the same conclusion, and by the selection of the same structures, has been a satisfaction to both.

Phylomylacris mantidioides (Goldenberg). Plate IX, fig. 1; Text-figure 39.

1867. *Blatta* or *Blattina*, Kirkby, Geol. Mag., vol. iv, p. 388, pl. xvii, figs. 6, 7.

1877. *Blattidium mantidioides*, Goldenberg, Fauna Sarsapont. Foss., vol. ii, p. 20.

1879. *Etblattina mantidioides*, Scudder, Mem. Bost. Soc. Nat. Hist., vol. iii, p. 72, pl. iii, fig. 6.

1906. (*Archimylacridæ*) *mantidioides*, Handlirsch, Die Fossilen Insekten, p. 237, pl. xxiv, fig. 27.

1919. *Archæotiphe mantidioides*, Pruvost, Faune Continent. Terr. Houill. N. France, p. 170.

Type.—Basal half of left tegmen in nodule; Kirkby Collection, Hancock Museum, Newcastle-on-Tyne.

Horizon and Locality.—Upper Coal Measures (zone of *Anthracomya phillipsii*); South Hylton, opposite Claxheugh on the Wear, Durham.

Specific Characters.—Surface of wing coriaceous. Costal margin convex; subcosta feeble, with few simple branches passing obliquely to the margin. Costal area acutely pyriform. Radius much divided, and occupying outer half of wing-apex. Median with numerous divisions, and passing to inner half of wing-apex.

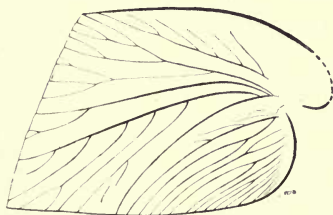


FIG. 39.—*Phylomylacris mantidioides* (Goldenberg); diagram of venation of type, a left fore-wing, three-and-a-half times natural size.—Upper Coal Measures (zone of *Anthracomya phillipsii*); South Hylton, opposite Claxheugh on the Wear, Durham. Hancock Mus., Newcastle-on-Tyne (Kirkby Coll.).

Cubitus large, extending to the distal end of the inner margin, and giving off five or more inner branches, the first and third dividing. Anal area tumid, anal furrow well defined. Anal veins 9—10 in number, the first forking twice, and also sending three weak branches forward. Inner margin convex, but less so than costal margin.

Description.—The surface of the nodule surrounding the wing-fragment is covered with the “spat” or young fry of a species of mollusc to which Kirkby gave the name of *Ancylus vinti*, but which I have since shown to be the young fry of *Anthracomya phillipsii* (‘Trans. Inst. Mining Engin.,’ vol. xlix, p. 675, 1915); also Trechmann and Woolacott (‘Geol. Mag.’ [6], vol. vi, p. 207, 1919).

The wing-fragment, measuring 13·5 mm. long and 8 mm. wide, is in excellent condition, and lies with the dorsal surface uppermost. The whole of the venation is well marked. Kirkby’s original figure is not correct, and his errors have been repeated by Scudder and Goldenberg. Goldenberg did not describe the species he named, and Scudder, to whom we owe the first detailed account, was hindered by the faulty drawing, and does not seem to have seen the specimen. Handlirsch removed the species from *Etblattina*, regarding the specimen as an indeterminate

form of the Archimylacridæ. Re-examination of the type-specimen shows errors in the earlier descriptions and figure, and I now re-describe and re-figure the type, placing it in the new genus established by Pruvost.

The wing is a stout structure, with a coriaceous surface which has enabled it to be perfectly preserved. The costal margin is well rounded inwardly at the base, and flattens over the middle of the wing. Assuming that it agreed with wings of a Phylomylacrid type, the margin would gradually merge distally into a broadly rounded apex.

The subcostal vein is the weakest of the whole series, and passes obliquely outwards, reaching the margin about the middle of the wing. It gives off five undivided branches which are oblique in direction, and fail to reach the margin.

The costal area is broad basally, and ends in an acute angle against the margin. It may be best described as pyriform.

The radius is a powerful vein, giving origin, in the inner third of the wing, to what seems to be a well-marked radial sector, and dividing into two equal branches a little further out. The outer of the two distal branches divides by twice forking into three twigs, which may have reached the middle of the outer margin. The inner of the two branches forks once only.

A wide area separates the radius from the subcosta over the greater part of its length, the widest interval being at the point where the radius divides into two main branches. The branch (? radial sector), of which but few divisions are shown on the wing-fragment, diverges inwardly from the main stem of the radius into the middle of the wing, giving off two branches, the first forking close to the broken edge of the nodule. From its position the ultimate divisions must have ended upon the outer half of the wing-apex, and the distal part of the outer wing-margin.

The various divisions of the radius are so divergent that they enclose a considerable portion of the whole wing, while they are equally well spaced out from the subcosta in front, and the median behind. The base of the radius stands up in relief, and owing to a little enfolding of the wing, overhangs the bases of the median and cubitus, but does not unite with them.

The median vein arises close to the radius, and like the latter, bends inwards at the base in a strong curve, which is continued until the direction is obliquely inward, when it becomes straightened.

At the summit of the basal curve the median sends off a short oblique vein inwards to the cubitus. This vein is a distinct commissure, and not an enlarged interstitial nervure. The significance of this commissural vein is not yet fully understood. Pruvost has recorded a similar structure in species of the genus *Archimylacris* (*op. cit.*, p. 151), and mentions that Scudder and Handlirsch have also indicated its occurrence in other forms. It is not, however, present in *Archimylacris woodwardi*, Bolton, and *A. hastata*, Bolton.

The median remains undivided in the proximal third of the wing, and then forks, the inner of the resultant veins again dividing on the broken edge. The areas on either side of the main stem of the median are, like those of the radius, well spaced.

The cubitus vein is less curved basally than the median and radius, well separated from the latter, and passing obliquely towards the distal end of the inner margin of the wing. It gives off six inward branches, the first arising near the base, and margins the anal furrow. The second branch gives off two irregular twigs which do not reach the margin, and the fourth is forked. The rest are undivided.

The whole of the anal area is remarkably well developed. It stands out as a tumid mass, marked off from the rest of the wing by the first branch of the cubitus, and with all the anal veins in high relief.

A broad area interposes between the first anal vein and the anal furrow, and upon this run out a few small and wavy veins which die out on the membrane. The first well-defined vein has a short stem dividing at once into two equal branches, which continue to the margin. The inner of these two branches either forks again, or has received the larger and distal portion of the next vein, the basal part being joined to the third vein, and forming an enclosed area. The next vein forks, and also the sixth, the remainder being closely packed together, and rapidly diminishing in strength and length as they crowd down upon the margin.

The interstitial neuration consists of a well-defined meshwork which shows a tendency to a longitudinal arrangement in the direction of the wing-margin.

Affinities.—The incorrect figure published by Kirkby has been a source of confusion, and probably accounts for Goldenberg's reference of the species to *Blattidium*, Scudder. At the time when he so referred it, Scudder had become familiar with the distinctive characters of wings of this type, and had created a new genus *Necymylacris* to receive them ('Mem. Boston Soc. Nat. Hist.,' vol. iii, p. 52, 1879). We can only account therefore for his reference of the wing to *Etblattina* on the score of the faulty drawing, as he does not seem to have seen the wing. The later drawing by Handlirsch is wrong in almost every detail, and his reference of the wing to the Archimylacridæ was the only one possible under the circumstances.

Scudder's genus *Necymylacris* was founded, not upon *N. lacoana*, as Handlirsch assumes (a fragment only of that wing being known), but upon *N. heros*. Handlirsch's later name of *Eumorphoblatta* ('Die Fossilen Insekten,' p. 195, 1906) is rightly reduced by Pruvost ('Ann. Soc. Géol. Nord,' vol. xli, p. 350, 1912) to the position of a synonym.

The figures of the three new species published by Pruvost in that paper are admirably reproduced, and as they show a complex of raised nervures in nearly

all the areas of the wings, such as is seen in the British specimen, and as the species agree among themselves while differing from the type of Scudder's genus *Necymylacris*, I considered them to represent a new genus, as already mentioned. In *N. heros* Scudder plainly shows an interstitial neurulation of closely-packed transverse nervures, which he describes as "a minute tracery of nearly straight, very closely approximated, excessively delicate, scarcely impressed, cross-lines."

Apart from this difference, there is a close relationship between *Necymylacris* and Pruvost's *Phylomylacris*. Regarding, as I do, the character of the interstitial neurulation, especially when well developed, as one of more than specific importance, I consider that *Phylomylacris* is a valid genus.

Genus **SOOMYLACRIS**, Handlirsch.

1906. *Soomylacris*, Handlirsch, Die Fossilen Insekten, p. 260.

Generic Characters.—Wings short and wide, being two to two-and-a-half times as long as wide. Costal area broadly triangular, the subdivisions of the subcosta arising from a central point, the inner branches only reaching the costal margin after a very oblique course. Radius with distinct radial sector. Median dividing low down into two main branches, while the cubitus is long, with simple or forked branches. Anal area large, nearly as long as the subcostal area, strongly convex, and crossed by numerous anal veins, the first usually thrice divided, both the subcostal and anal areas extending nearly to the middle of the wing.

Soomylacris deanensis (Scudder). Plate IX, fig. 2; Text-figure 40.

1895. *Etolblattina deanensis*, Scudder (in part), Bull. U.S. Geol. Surv., no. 124, p. 34, pl. xii, fig. 1.

1896. *Etolblattina deanensis*, Scudder, Geol. Mag. [4], vol. iii, p. 12, fig. 1.

1906. *Soomylacris deanensis*, Handlirsch, Die Fossilen Insekten, p. 260, pl. xxvii, fig. 15.

Type.—Right tegmen, lower view, lacking apical portion; U.S. National Museum, Washington (Lacoe Collection, no. H. 2132b; Nat. Mus. no. 38090).

Horizon and Locality.—Coal Measures; Foxe's Bridge, Forest of Dean, Gloucestershire.

Description.—Scudder described and figured two specimens from the Forest of Dean under the name of *Etolblattina deanensis*, but the second is dealt with in this monograph under the new specific name of *Soomylacris stocki* (see p. 130).

The type tegmen of *S. deanensis* has a length of 25 mm., and a maximum breadth of 13 mm. across the anal area. Scudder gives the length as 38 mm., but the wing has lost a second portion of the apical end since he figured the specimen. The anal area is broken, and has become slightly displaced along the line of the anal furrow, but to so slight an extent as not to hinder measurement.

The costal margin is strongly convex basally, becoming almost straight over the middle of the wing, in this respect differing from *S. stocki*, which is increasingly convex in the middle of the wing—a fact noted by Scudder. The inner margin is more nearly straight, and the wing narrows as the apex is reached, the maximum width being across the anal area.

The subcosta is made up of three main branches, the first forking into two equal twigs, the second forking twice into three twigs, and the third forking three times into four twigs. The subcostal area is very wide basally, and terminates in an acuminate angle beyond the junction of the first and second thirds of the wing.

The radius is a powerful vein dividing low down into two main branches, the outer breaking up into four twigs by a trifid forking, while the inner branch forks into two, and each of these into two again, the two twigs of the inner secondary fork each dividing into two. The radius thus ends on the broken edge of the wing in ten twigs.

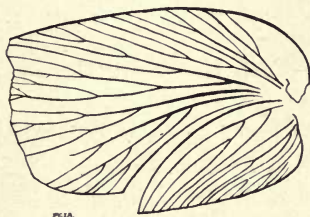


FIG. 40.—*Soomylacris deanensis* (Scudder); diagram of venation of right tegmen (the diagram reversed), twice natural size.—Coal Measures; Foxe's Bridge, Forest of Dean, Glos. U.S. National Museum, Washington (Lacey Coll., no. H. 2132 b; Nat. Mus. no. 38090).

The median vein forks into two main branches at about the end of the proximal third of the wing. The outer branch divides into two equal twigs, the inner forking again further out. The inner branch forks once only on that portion of the wing which is now preserved, although Scudder has figured it as breaking up into six ultimate twigs by repeated forking of the innermost of the two branches now seen. Scudder shows twelve twigs of the median ending on the inner half of the wing-apex, while the actual specimen now shows only five. Scudder is wrong in showing a twig coming off inwardly from the first main division of the median, and dying out in the wing-membrane. The appearance is due to a slight furrow on the impression. This furrow can be traced across the branches of the adjoining cubitus.

The cubitus, like the median, is sigmoidally curved, and gives off five inward branches, and ends upon the distal end of the inner margin in a small fork. The second and third branches of the cubitus fork twice, and end on the margin in three twigs each.

Unlike the rest of the wing, which is flatly convex, the anal area is well rounded, and must have projected somewhat above the general surface. It is

crossed by six anal veins, the first being a large structure breaking up into four branches, and more widely separated from the anal furrow proximally than is its outer branch distally. The second vein is simple. The third forks twice, and ends in three twigs. The fourth and fifth fork once each. Traces of two more anal veins are seen on the margin.

The interstitial neuration can only be distinguished clearly in the anal area, and consists of irregular cross-nervures which cross the main veins and unite laterally to form a meshwork, which is not, however, of a strictly reticulate character.

Soomylacris stocki, sp. nov. Plate IX, fig. 3; Text-figure 41.

1895. *Etolblattina deanensis*, Scudder (in part), Bull. U.S. Geol. Surv., no. 124, p. 34, pl. xii, fig. 3.

1896. *Etolblattina deanensis*, Scudder, Geol. Mag. [4], vol. iii, p. 12, fig. 2.

1906. *Soomylacris deanensis*, Handlirsch, Die Fossilen Insekten, p. 260, pl. xxvii, fig. 16.

Horizon and Locality.—Coal Measures; Crump Meadow, Forest of Dean, Gloucestershire.

Type.—Fragments of two tegmina; U.S. National Museum, Washington (Lacoe Collection, no. H. 2132 c; Nat. Mus. no. 38090).

Description.—The fragment of a left tegmen has lost much of its base and apex, while the greater part of the anal area is obscured by the anal area of the presumably opposite right tegmen. It lies with the under-surface uppermost, the anal area of the second tegmen being right side uppermost. Feeble traces of what appear to be a hind-wing can be distinguished through the fragment of tegmen, and project a little beyond its margin at one point. The specimens are on a dark grey shale in which occur numerous remains of *Neuropteris*, *Annularia*, etc.

The outer margin is seen on the displaced shoulder of the wing, and on the portion of the outer half of the wing that remains. It is more convex than in *S. deanensis*, and the shoulder bends inwards almost at a right-angle, that of *S. deanensis* being regularly rounded.

The subcosta is represented by the bases of three stout veins which spring from the same point, all showing forking, and by two straight veins running out on the costal margin on the fragment. These two seem to be the terminals of the innermost forking seen on the shoulder of the wing. The intercostal area is broader than that of *S. deanensis*. The base of the radius is missing, and the union of the two twigs into which the outer branch divides is missing. Each of these twigs forks again half-way between its origin and the margin.

The inner branch of the radius divides by twice forking, and the inner of the resultant twigs forks again, so that the radius ends on the margin in at least nine twigs.

The median forks equally twice, the inner of the four twigs again forking twice into three.

The cubitus is a simpler structure than that of *S. deanensis*. It consists of a sigmoidally curved main stem giving off five inward branches, the first and third only forking. The cubitus, therefore, ends on the inner margin in eight twigs, that of *S. deanensis* in eleven.

The anal area of the right tegmen is superficially much like that of *S. deanensis*, but the first anal vein gives off three branches in place of two, the innermost forking. In *S. deanensis* the middle branch forks. The second vein forks twice, that of *S. deanensis* being undivided; the third forks once into two twigs, that of *S. deanensis* having three; the fourth forks once, the fifth is undivided, and the sixth forks twice into three twigs. Traces of a seventh vein are present. Portions of the anal area are shown near the inner margin, and above the outer edge of the anal area of the right wing, but they are too fragmentary to determine the course of the veins.

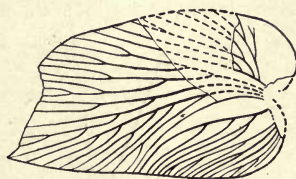


FIG. 41.—*Soomylacris stocki*, sp. nov.; diagram of venation of two tegmina, twice natural size.—Coal Measures; Crump Meadow, Forest of Dean, Glos. U.S. National Museum, Washington (Laceo Coll., no. H. 2132c; Nat. Mus. no. 38090).

The inner margin is almost straight, and owing to the greater convexity of the outer margin, the wing appears to have been narrower apically than *S. deanensis*.

The interstitial neurulation is similar to that of *S. deanensis*. Traces of possibly one of the hind-wings can be seen underneath the costal margin and under the outer twigs of the radius. The wing is closely related to that of *S. deanensis*, but the differences, especially in the cubitus, are sufficient to distinguish the two.

***Soomylacris burri*, Bolton.** Plate IX, fig. 4; Text-figure 42.

1912. *Soomylacris (Etoblattina) burri*, Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 318, pl. xxxiii, figs. 1, 2.

Type.—Left tegmen; Museum of the Kent Coal Concessions Co., Dover.

Horizon and Locality.—Coal Measures (dark shale from a depth of 1208 feet); Barfreston Boring, Kent.

Specific Characters.—Subcosta with few divisions. Radius with well-marked radial sector, which is well developed and much divided. Median with two main

divisions. Cubitus large, with six simple branches. Anal area very wide basally, and with 4—6 veins. Tegmen tapering along both margins to the apex.

Description.—The tegmen lies with the under surface uppermost, lacking only a small portion of the wing-apex. It is short and broad, measuring 14 mm. long and 8 mm. wide. The dorsal surface is convex, the exposed under surface being concave.

The costal margin is rounded, especially in the basal portion of the subcostal area. Distally the margin curves into the wing-apex, which is bluntly rounded. The inner margin curves outwards in its distal half, so that the wing is widest basally, and narrows into the wing-apex.

The subcosta is a strong vein with few branches, the first two being simple, and passing out obliquely. A forked branch arises further out, and near the margin of the wing a single simple branch. The costal area is broad basally, and well rounded.

The radius is a large, much-divided vein, occupying, with the subcosta, the outer half of the wing. It is short, and gives off a radial sector in the basal

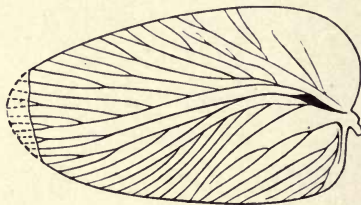


FIG. 42.—*Soomylacris burri*, Bolton; diagram of venation of left tegmen, four times natural size.—Coal Measures (dark shale from a depth of 1208 ft.); Barfreston Boring, Kent. Mus. Kent Coal Concessions Co., Dover.

fourth, afterwards passing out obliquely to the outer margin, and giving off four outward branches, the first irregular in its course, and with two feeble twigs which do not reach the margin, the second and third forking well out, and the fourth small and undivided. The radial sector passes straight to the wing-apex, giving off six strong branches, the first, second, and fourth forking, the rest remaining undivided.

The median is convexly curved basally, and bent inwards to the inner margin. It gives off a strong forward triple-divided branch in the basal fourth, and further out a second branch, which forks three times into four branches. The eight divisions of the median end on the distal third of the inner margin and part of the apex.

The cubitus describes a regular sigmoidal curve, and gives off at regular intervals a series of six inwardly directed branches, all of which are undivided.

The anal area is very wide basally, and crossed by 4—6 veins, the first forking twice, the second once, the third undivided, and the fourth forked. Traces of two

very small anal veins are also seen in the curve of the wing-margin. The anal area is strongly convex between the anal furrow and the first anal vein.

The interstitial neuration of the anal area appears to consist of straight cross-nervures. Over the rest of the wing the interstitial neuration cannot be made out.

Affinities.—When first describing this species, I regarded it as closely allied to forms which Handlirsch has placed in his genus *Hemimylacris*. There can be no doubt, from what has been already said, that a close relationship exists. Pruvost (*op. cit.*, pp. 222—4) has recorded two species of *Soomylacris* from the Lens and Liévin Coalfields of Northern France, *S. liévinensis*, Pruv., and *S. aff. deanensis*. The occurrence of these British species may serve to indicate the Westphalian affinities of the Kent and Forest of Dean Coalfields.

Genus **ORTHOMYLACRIS**, Handlirsch.

1906. *Orthomylacris*, Handlirsch, Proc. U.S. Nat. Mus., vol. xxix, p. 768.

Generic Characters.—Tegmina two to two-and-a-half times as long as wide, with a sub-cordate outline. Costal area extending from one-half to two-thirds the length of the tegmen. Radius extending to the tegmen-apex, and giving off a large number of outward branches. Median with few veins, directed towards the apex and the inner margin. Cubitus never reaching the apical margin, and with few branches. Anal area at least twice as long as high. Structure leathery, and with cross-wrinkles.

Orthomylacris lanceolata, Bolton. Plate IX, fig. 5; Text-figure 43.

1911. *Orthomylacris lanceolata*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 167, pl. x, figs. 1, 2.

Type.—Left tegmen; Museum of Practical Geology, Jermyn Street (no. 24511).

Horizon and Locality.—Coal Measures (shales associated with the Graigola Seam, Pennant Series); Clydach Merthyr Colliery, Clydach Valley, Swansea Vale, Glam.

Specific Characters.—Tegmen long, and uniformly tapering to the apex. Upper surface regularly convex. Subcostal area broadly triangular, with oblique branches. Radius much branched. Median unbranched in basal half, with three outer branches. Cubitus divided into two main branches, the outer forking into two equal twigs, and the inner giving off three inward twigs, the first only forking. Outer and inner margins convex.

Description.—The tegmen, which measures 23 mm. long and 10 mm. wide, lies with the dorsal surface uppermost, and is gently rounded along its length, a slight flattening only being visible over the middle of the outer margin. The uniform tapering of the two margins to the apex produces an elongate form of tegmen of an unusual type among Blattoids. The base of the tegmen is lost, and the costal area appears therefore to occupy nearly half the outer margin.

The subcosta is thin, sunk in the tegminal structure, and gives off three forked branches which pass in straight oblique lines to the margin.

The radius is a large vein, with four branches, the first three doubly-forked and the last undivided. The main stem of the radius is convex in the basal part of its length, and concave in the outer half. The branches pass out very obliquely and extend on to the apical margin.

The median divides about the middle of the tegmen, on a level with the third branch of the radius. It gives off three branches, the first forking twice into four equal twigs, the second of the series forking again near the margin. The inner pair of twigs unite in the middle of their length, and separate again further out, so that a lenticular "cell" is produced. The second branch is undivided. The third branch divides into a long outer twig which bends forwards towards the apex, and a smaller and weaker twig which goes straight out to the inner margin. There is, as a result of this separation, a wide part of the inner margin destitute of veins.

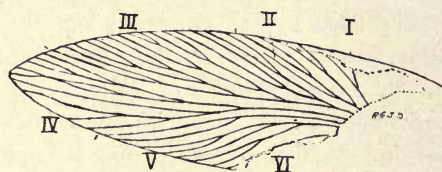


FIG. 43.—*Orthomylaeris lanceolata*, Bolton; diagram of venation of left tegmen, three times natural size.—Coal Measures (shales associated with the Graigola Seam, Pennant Series); Clydach Merthyr Colliery, Clydach Valley, Swansea Vale, Glam. Mus. Pract. Geol. (no. 24511). Numbering of veins as in Text-figure 33, p. 104.

The cubitus arises close to the median, and at once divides into two main branches, the outer being forked once only, and the inner giving off a forked branch succeeded by two which are undivided.

The anal area has broken away along the line of the anal furrow. It is shorter than the subcostal area.

The interstitial neuration cannot be determined with certainty. The surface near the apex is marked by cross-wrinkles, but I cannot affirm that this is a part of the neuration.

LARVAL BLATTOIDS.

(*Blattoidea*) *peachi* (Woodward). Plate IX, fig. 6.

1887. *Etblattina peachii*, Woodward, Geol. Mag. [3], vol. iv, p. 433, pl. xii, fig. 1.

1906. (*Blattoidea*) *peachii*, Handlirsch, Die Fossilen Insekten, p. 178, pl. xviii, fig. 26.

Type.—Upper surface of head, pronotum, rudimentary wings, and broad segmented abdomen, in nodule of fine grey sandstone; Kilmarnock Museum.

Horizon and Locality.—Coal Measures ("grey sandy shale with nodules of impure clay and ironstone" at 91 ft. 6 in. below the surface); Greenhill Pit, Kilmarnock.

Description.—The length of the insect is 23 mm. and its width across the forewings 15 mm. The pronotum is 12 mm. wide, and 5 mm. long. The abdomen is 12 mm. long and diminishes in width from before backwards. The coarse character of the stone has obliterated or failed to preserve all the finer detail of the specimen, but the insect still retains the gently convex dorsal surface which it doubtless had during life.

The very small head, not well defined, is apparently divided into two small anterior and two larger posterior areas by shallow longitudinal and transverse grooves. No appendages are visible. A raised ∇ -shaped portion of the matrix in front of the head may indicate that it formerly extended beyond the line of the pronotum. The two anterior plates covering the head are notched in a small ∇ on the middle outer edge.

The pronotum is nearly two-and-a-half times as wide as long, with rounded latero-posterior angles and almost straight posterior border. The front border forms a semicircle, recessed in the middle, and enclosing the head-shield termed by Dr. Henry Woodward an "epicranial plate."

Two pairs of rudimentary wings are present, the first pair articulating well forward, as if attached to the mesonotum under the hinder margin of the pronotum; the hinder pair being joined to the metanotum nearer the middle line. The wings are about 10 mm. long and 5 mm. wide, with blunt apical angles. The front pair of wings have begun to take on the character of tegmina, being stouter than the inner pair.

The venation of the wings is but faintly indicated. Woodward has stated that the "mediastinal" vein and the veins of the anal and intermedian area are seen in all four wings. In present nomenclature this means that the subcosta and the cubitus are present, with some traces of the anal veins.

This seems hardly to be the case. The left hind-wing has the veins best marked, and all that can be said is, that there are indications of a few short, thick veins passing from near the attachment of the wing towards the inner margin, and crossing the middle of the wing. The condition is much like that figured by Comstock and Needham ('Amer. Nat.' [4], vol. xxxii, p. 773, fig. 56, 1898) in the hind-wing of the nymph of a cockroach, except that the veins in the Kilmarnock specimen spread fanwise, instead of keeping in close order down to the wing-apex. The veins present will therefore agree best with the radius, median and cubitus. The vein which I consider the radius is nearly parallel with the outer margin and better defined than the rest.

The length of the mesonotum and metanotum together is 6 mm. Neither is well seen owing to the overlap of the wing-bases.

The abdomen is in excellent preservation, and has several features of interest. It is 12 mm. in length, diminishing from a breadth of 10 mm. across the body and expanded epimera to 3.5 mm. across the ninth segment. The central axis of the abdomen is more convex than the lateral epimera, and the middle line is slightly ridged. The abdomen forms about one-third of the total breadth, being 4 mm. wide in the first segment, diminishing to 1.5 mm. on the ninth segment. The tenth segment is missing.

The epimera are broad, with slightly thickened posterior edges. From the posterior dorsal margins of the first to fourth segments arise thin plate-like expansions. These pass back over the succeeding two segments, showing ragged edges, as if they had a greater extension during life, and had since been partially torn away. The precise relation of these structures to the segments is not quite clear. On the right side of the first, second and third segments, these processes seem to emerge from beneath the hinder edges of the terga. If they do not, but are continuous with the hinder edge, they are yet distinct from the latter, as the suture-line between the adjacent terga can be traced outwards along the front edge of the epimera, and if the two are united this furrow may have functioned as a joint.

The undeveloped wings, scarcely wider than the pronotum, and the broad epimera of the abdomen, clearly indicate the larval condition of the specimen. It must be more advanced towards the adult stage than *Leptoblattina exilis*, Woodward., from the Coal Measures of Coseley, Staffordshire, as it differs considerably in the greater breadth of the abdomen and the development of the epimera.

In size (*Blattoidea*) *peachi* is two-thirds the length of such an adult form as *Aphthoroblattina johnsoni* (Woodw.), and as size is fairly well correlated with development in Blattoids, we may assume that the insect had not fully reached the nymph stage. This conclusion seems to be also confirmed by comparison with the wing-length of *L. exilis*, where the wings are double the length of the pronotum.

The absence of determinable details in the wings prevents any successful attempt to assign the specimen to a position in any accepted classification. The most that can be said is, that the great breadth of the pronotum, as contrasted with the length, would seem to indicate a relationship with the Mylacridæ.

***Leptoblattina exilis*, Woodward. Plate IX, figs. 7, 8.**

1887. *Leptoblattina exilis*, Woodward, Geol. Mag. [3], vol. iv, p. 56, pl. ii, figs. 2, 3.

1906. (*Blattoidea*) *exilis*, Handlirsch, Die Fossilen Insekten, p. 173, pl. xvii, figs. 16, 17.

Type.—Nearly perfect larval blattoid in an ironstone nodule; British Museum, Johnson Collection (no. 1065).

Horizon and Locality.—Middle Coal Measures (binds between the “Brooch” and “Thick” coals); Coseley, Staffs.

Description.—The type-specimen and a second (no. 1066), described at the same time, show an almost complete pronotum, two pairs of rudimentary wings, and a long jointed abdomen. Dr. Henry Woodward recognises a portion of the head projecting in front of the pronotum in each, but of this I am doubtful. He also describes the head as follows: “The head is very small, and somewhat bluntly pyramidal in form, and measures 2 mm. in breadth at its base, where it disappears beneath the pronotum, and is 2 mm. in length. There is a suture visible down the centre which divides the two epicranial plates, at the sides of which the eyes would be seen; in front of the epicranium a small projection no doubt represents the clypeus with the labrum at its extremity.”

In the type-specimen (Pl. IX, fig. 7) the pronotum, 7.5 mm. long and 9 mm. wide, is well rounded in front and on the sides, the margin of the latter passing by blunt rounded angles into an almost straight hinder border. The surface is marked out into the usual central raised area, bordered by slight grooves which deepen backwards, and curve inwards. The lateral portions are flattened.

The dorsal part of the mesonotum is partially exposed, its anterior edge being hidden beneath the pronotum. The front pair of wings is attached to the mesonotum so far forward as to touch the hinder edge of the pronotum. The surface of the mesonotum was originally rounded, and judging from its present condition, somewhat thin. It is now slightly puckered by folding.

The metanotum is similar in character to the mesonotum, but a little more robust, and has the second pair of wings still articulated near the front margin.

The abdomen is long, the segments immediately following the body being flattened by pressure, and their boundaries not clearly discernible. Behind follow at least five well-marked segments which decrease in diameter backwards. The last three show lateral epimera with the points turned backwards. Traces of what appear to be cerci follow the last segment. These seem to be curved inwards at their tips, and widely spaced, but their definition is unsatisfactory. The length of the abdomen behind the metanotum is 14 mm., and the last segment is not more than 2 mm. wide, the first of the six segments being double that diameter.

The wings are short, stout structures, those of the right side being perfect, and those of the left side incomplete. The right tegmen has a length of 11 mm., and the hind-wing a length of 10 mm. The venation, as in all larval wings, is very obscure, and can be best studied on the impression of the wings. It consists of a stout vein passing from the point of articulation of the wing outwards towards the wing-apex, and keeping close and parallel with the outer margin. From this vein a series of fine branches spreads fan-wise towards the inner margin of the wing, and seems to reach it. Woodward has recognised a mediastinal (subcostal) vein

and an anal vein. An examination of a good cast of the specimen by oblique light shows that there are a strong outer vein parallel with the outer margin, and at least two others with short, thick stems breaking up into a fan-like series of oblique veins which spread out towards the inner margin. From the researches of Messrs. Comstock and Needham (1899, 'American Naturalist' [4], vol. xxxiii, pp. 573-582, fig. 74), these veins seem recognisable as the radius, median and anal. I am unable to distinguish any detached limb such as that mentioned by Woodward.

The second example (Pl. IX, fig. 8) differs from the first in several small details. It lies on an inclined surface, and the abdomen has been dislocated and twisted over to the right, so that it is in a different plane from the rest of the insect.

The small "head" described by Woodward can be seen projecting from the middle of the frontal margin of the pronotum, which is a little broken away. It consists of a wedge-shaped structure, which narrows forwards, broad at its base and slightly swollen. It is divided into an anterior centrally placed plate of quadrangular outline, the hinder angle joining a sunken line (suture?) dividing the two basal plates, which Woodward terms "epicranial." Too little is seen of the anterior central plate for description, or for its recognition as a labrum.

The pronotum is raised in the centre and hollowed on the sides, while the hinder margin is partially broken away. It overhangs the bases of the first pair of wings. A ridge runs down the median line of the pronotum, the sides of the latter being less rotund than in the first specimen, and the whole pronotum is more sub-pyramidal in form.

The first pair of wings is still in place, and about 11 mm. in length, allowing for the basal part hidden under the hinder margin of the pronotum. The wings stand out at a low angle from the body, leaving the mesonotum and metanotum exposed. Both are partially crushed and crumpled, and the characters cannot be made out. The left wing is the better marked of the two.

The outer margin of the wing of the first pair is stout, and raised above the general level. Two stout ridges rise from the middle of the base and pass along the wing, the second ridge being the strongest, and traceable over two-thirds of the length, while the first ridge does not extend beyond the basal fourth. The first ridge occupies the place of the subcostal vein, and dies out in the direction of the outer margin, but with no evident branches. The second and larger ridge has all the appearance of a radius, is parallel with the outer margin, and can be seen to send off four branches to the middle of the wing-apex, and the inner half of it. The anal area is more slightly ridged, but with no discernible divisions.

The hind-wings have a straighter outer margin than the fore-wings, and are more membranous. Very little is seen of the left hind-wing. The outer margin of the right hind-wing seems to be folded back on itself, and the radius vein is the first distinguishable. It is more branched than its fellow of the fore-wing, giving

off at least five branches, the fourth being forked. These branches reach a portion of the outer side, and apex of the wing, and the whole of the inner side of the apical margin. More inward is seen the distal half of another vein which may be the median. It separates into two branches which reach the distal part of the inner margin. The anal area is hidden by being folded in against the body.

The wings appear too small and of too rigid a type to have been serviceable for flight, and the elongated abdomen could not have been supported by such rudimentary wings. The size and condition of the hind-wings shows that the great increase in width over that of the tegmina in the adult form is a comparatively late development, and probably synchronised with the shortening up of the abdomen.

The proximal segments of the abdomen are obscure, but beyond the dislocation can be seen four well-rounded segments, followed by the crushed terminal segment and indications of one of the cerci.

Affinities.—The generic name attached to these specimens by Dr. Woodward is of doubtful value, since in the present state of our knowledge it is impossible to assign larvæ to the adult forms of which they are the immature representatives. The only adult forms known from the same beds are *Archimylacris johnsoni*, *A. eggintoni* and *A. incisa*.

Order PROTODONATA (Brongniart), Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 304.

Large insects with slender bodies similar to those of the Odonata. Wings large, outspread in the condition of rest, and only capable of an up and down movement in one place. Wing-venuration specialised by the union of several longitudinal veins into accessory or interpolated sectors. Cross-nervures well developed in a regular order. Head large, with large eyes and powerful jaws; thorax much as in the Odonata. Legs strong and similar. Antennæ short. Abdomen long.

Family MEGANEURIDÆ, Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 306.

Wings Protodonate in character, with a pre-costal marginal area destitute of veins. Costa almost straight; subcosta simple, and uniting with the costa far out. Radius simple, and followed by a series of accessory veins which represent the radial sector, these all curving towards the distal inner margin. Median

apparently united to the radius at the base, and dividing about the middle of the wing into two widely divergent branches, between which are developed a numerous series of accessory veins. Cubitus (in the type species) consisting of a single undivided vein on the outer side, and of an inner branch which is much subdivided. Anal vein reaching middle of inner margin, and giving off many strongly recurved branches. Inner margin broadly convex. Interstitial neuration consisting of numerous series of straight cross-nervures. Wings membranous.

This family was formed for a small group of insects of enormous size, discovered at Commentry and described by Brongniart.

Genus **MEGANEURA**, Brongniart.

1885. *Meganeura*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 60.

Generic Characters.—Gigantic insects with long narrow fore-wings and broader hind-wings. Precostal area extending to the middle of the outer margin. Costa almost straight, powerful, and joined far out by the subcosta. Radius a single strong vein, followed by a radial sector arising from the radius in the fore-wing, and in the hind-wing from the outer branch of the median. Median united with the radius at the base, having a simple outer branch and a much divided inner branch. Many of the branches of the latter accessory. Cubitus with outer and inner branches dividing at the base of the wing, and curved in an S-shape. The inner branch well divided, the outer feebly so. Anal veins numerous, strongly curved to the inner margin.

Genus **BOLTONITES**, Handlirsch.

1919. *Boltonites*, Handlirsch, Revision der Paläozoischen Insekten, p. 61.

Generic Characters.—Pre-costal field very small; cubitus and anal veins much as in *Gilsonia titana*, Meunier. "The bridge clearly preserved." By this I understand that Handlirsch alludes to the transverse vein which I described as an "oblique inward branch of the cubitus joining on to the anal." Cubitus and anal with few branches.

Boltonites radstockensis (Bolton). Plate X, fig. 1; Text-figure 44.

1914. *Meganeura radstockensis*, Bolton, Quart. Journ. Geol. Soc., vol. lxx, p. 119, pls. xviii, xix.

1919. *Boltonites radstockensis*, Handlirsch, Revision der Paläozoischen Insekten, p. 61.

Specific Characters.—Outer wing-margin thickened, coriaceous and tubercular. Outer and inner wing-margins spinulose. Cubital-anal vein present. Areolæ

(? aborted spiracles) in anal area. Length of wing when complete about 190 mm. or seven and a half inches.

Type.—Proximal third of wing, in dark shale with plant-remains; Sedgwick Museum, Cambridge.

Horizon and Locality.—Upper Coal Measures; Tynning Colliery, Radstock, Somersetshire. Precise horizon uncertain.

Description.—The fragment consists of the proximal portion only of a wing, 64 mm. long and 40 mm. in greatest width, and appears to have formed about one-third of the whole. The wing has also been broken along the middle, and a portion lost, due apparently to the shale breaking irregularly, and leaving an uneven surface. The outer and inner parts of the wing-fragment still retain their normal position relatively to each other, but a portion of the inner part of the base is missing.

The outer part of the specimen consists of two veins, the costa and sub-costa. The inner portion shows the cubital and anal veins. The veins missing are therefore the radius and median.

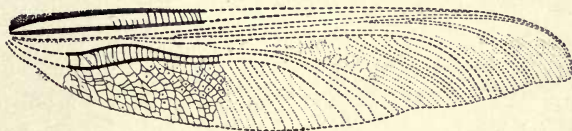


FIG. 44.—*Boltonites radstockensis* (Bolton); restoration of right wing, based on that of *Meganeura monyi*, Brongt., one-half natural size. Upper Coal Measures (precise horizon uncertain); Tynning Colliery, Radstock, Somerset. Sedgwick Museum, Cambridge.

The outer wing-margin consists, not of a free alar expansion, as is usual in the Protodonata, but of a coriaceous and tuberculated mass, which is well marked off from the costa along its whole length. This thickened mass apparently represents the free alar development seen in other members of the group.

That other veins existed in the middle area of the wing is proved by the remains of three short portions of a vein, lying in the middle of the interspace. Not until these fragmentary vein-structures had been perceived, and the type of *Meganeura monyi* studied in the Museum at the Jardin des Plantes, Paris, could its relationship with the Protodonata be confirmed. The direct comparison of the two wings also showed that the Radstock specimen had the same parallelism of the principal veins, the co-existence of similar cross-veins, and the same distinctive character of the anal area as *M. monyi*.

The basal portion of the outer margin of the Radstock wing is swollen into an elongated mass, which thins out distally, and probably did not extend beyond the proximal third of the wing. It can be traced for a length of 20 mm., and near the articulation is covered with numerous low, smooth-topped tubercles, arranged

irregularly. The more median part of the costal margin appears as a flat, straight, knife-like edge, crossed by a series of fine striations.

The thickened pre-costal portion of the outer margin forms a rigid bar, enormously strengthening the wing for flight. The costa is distinct, and passes directly to the wing-apex, as a broad, strap-shaped vein, broadest at its point of origin, and slowly diminishing in width to the tip of the wing.

The subcosta has an apparent union at its base with the costa, but this is due to a slight backward displacement of the latter. Some distance beyond the thickened margin, the costa bears, at regular intervals, a series of low spines, projecting freely forwards, and gradually inclining towards the wing-apex. A few scattered tubercles, and a faint ridge, are seen along the middle of the vein, and eventually die out. The distal part of the costa is straight, and is joined to the subcosta by a series of transverse branches which are well marked. Of these branches, eleven are still whole, and portions of nine others can be made out. It would therefore seem that the whole of the costal area was covered by a parallel system of straight cross-branches with no intervening network.

The subcosta arises in close contact with the costa, diverging rapidly until the two are about 5—6 mm. apart. Once this distance has been attained, they remain nearly parallel for some distance. There are indications that the two come together some distance beyond the broken edge of the wing-fragment.

The costa and subcosta are nowhere more than 5—6 mm. apart, in the main but 4 mm., the interval narrowing to the broken edge of the wing. While the subcosta has the same flat, strap-shaped character as the costa, it is more delicate, and a narrower vein. A few tubercles are disposed along the median line of its length.

The radius and median veins being lost, except for the trivial pieces already noted, they cannot be compared with those of *Meganeura*. In the French species of this genus a complex of parallel veins arises from one or two roots between the subcosta and the cubitus. In the case of *M. mōnyi*, this complex arises from a strong radius and a weak median. In *M. selysii* it would appear that the radius and median are united at their base. In the restoration of the Radstock wing it will be seen that the vein-fragments appear as parts of the median vein, the radius being wholly lost.

The cubitus is separated from the outer part of the wing by the interval formerly occupied by the radius and median. This interval is variable in width, owing to the strong curvature of the cubitus. This is a large flattened vein, strongly flexuous, and finally curving inwards to reach the middle of the inner margin. The base of the vein has been broken away and lost, but its course may be indicated by a faint groove which curves forward towards the base of the subcosta. The outer inward curve of the cubitus is the greater, so that the interval between the radius and the subcosta becomes increasingly wide, thus

agreeing exactly with what obtains in the same part of the wing in *Meganeura monyi*. It is an indication of the rapid inward curvature which takes place a little further out, and of the presence in the complete wing of the wide distal area occupied by the many branches of the radius and the median.

Close to the basal broken end of the cubitus a strong oblique inward vein is given off, which reaches the anal vein, and fuses with it. At the time when I first described this wing I wrote as follows: "It has the appearance of an important commissure between the cubitus and the anal, or of a posterior branch of the former which has fused with the latter." Since then, Dr. R. J. Tillyard has published the results of his studies on recent dragon-flies ('The Biology of Dragon-flies,' Cambridge University Press, 1917), in which he notes our discovery of this oblique vein. He recognises it as an anal-cubital vein which he had previously ('Proc. Linn. Soc., N.S.W.,' vol. xxxix, pp. 163—216, 1914) described as indicating the point where the true anal vein diverges from the cubitus. He concludes (*op. cit.*, p. 305): "Hence it would appear that *Cu* (cubitus) and *A* (anal) were fused basally as in all recent forms. Thus the gap between Protodonata and Odonata is being gradually lessened until to-day we may almost certainly see in the Meganeuridæ the giant relatives of the direct ancestors of some at least of our recent families."

Beyond this anal-cubitus vein the cubitus is joined to the anal by a system of parallel slightly curved branches, similar in character to those which unite the sub-costa and the costa. No fewer than twenty-five of these branches can be distinguished. Basally to the anal-cubital vein are two transverse branches, a little more curved than the rest. As in the costa and sub-costa, a median line of tubercular ornament is present.

The anal vein is strongly marked, and its course is much similar to that of the cubitus, but the second inward flexure is less marked, so that the two veins are closer together in the middle of their length, and more widely separated basally. The anal gives origin, along the whole length of its hinder margin, to a series of branches, which arise at slightly increasing intervals, being closest basally, and most widely separated between the twelfth and thirteenth branches, beyond which the interspaces narrow again to the fifteenth branch. The basal branches pass in straight or slightly oblique lines inwards to the wing-margin. Further out they become curved, with the convexity outwards. The twelfth branch is a strong and important vein, sweeping in a powerful double curve distally, and inwardly to the wing-margin. It corresponds in position to Brongniart's "vein X." Beyond it are the remains of three feeble branches, which bend in simple curves to the margin.

The spaces between the anal branches are divided up into a series of quadrangular areas or cellules, by a great series of secondary branches, arising at right-angles. The twelfth dorsal branch stands out from the rest by reason of its

robust character and sweeping curve, and gives off, on its inner side, a series of twigs, which divide and separate so widely that first a double and then a treble series of cellules are enclosed between them. On its distal side it intercepts five branches arising from the inner border of the main stem of the anal, the enclosed quadrangular areas being increasingly elongated antero-posteriorly up to the eighteenth branch, the course of that branch to the margin being uninterrupted. The integument in many of the quadrangular areas or cellules is marked by a slight central elevation, which, under high magnification, presents the appearance of a circular thickened lip, with a central depression or perforation. These structures have no regularity of arrangement, but are most numerous on each side of the twelfth branch of the anal. The integument within the cellules is, in some instances, obliquely wrinkled. These structures appear to resemble aborted spiracles.

The inner margin of the wing is sharply sloped forwards from the broken edge onwards to the point of attachment, and is well-defined and spinous along the whole or the greater part of its length. The spines are low, directed distally, and in character somewhat like those on the outer margin of the wing. They are not so clearly shown, however, and they may not be truly marginal, as it is a matter of doubt whether the integument stretches a little outside them. I incline to the latter view. The ventral surface of the wing seems to be uppermost, in which case the wing-fragment is the proximal portion of a right wing.

Affinities.—The general characters of the wing-fragment are those typical of the genus *Meganeura*, and it cannot be confused with the genus *Paralagus*. It is, however, unlike *M. monyi*, in which the development of marginal spines has not been recorded, and the tuberculation so characteristic of the Radstock wing is not shown in that species. *M. monyi* is a wider and longer wing, and does not possess the areolæ seen in the quadrangular cellules of this species.

Considered as a Meganeurid wing, the Radstock specimen is no primitive structure, but highly specialised, an anal cubitus connection is present, the costal border has become thickened and tuberculated, and a secondary development of spinules and tuberculations has arisen.

INCERTÆ SEDIS.

Genus **TILLYARDIA**, novum.

Generic Characters.—Wings elongated, five times as long as wide. Subcosta short; radius simple, radial sector forming an accessory vein with several divisions. Median vein with few branches. Cubitus with two main branches, the inner much

divided. Accessory sectors present. Interstitial neuration forming a regular series of straight cross-nervures.

I refer to this genus a highly specialised wing from the Scottish Coal Measures, which is unlike any other Carboniferous wing that I know. It is at once suggestive of the Palæodictyoptera and of the Protodonata, but belongs, I believe, to the latter Order. Where shown, the neuration of the wing is clear, and the absence of the outer part of the base, and the central portion of the wing, renders it difficult to determine the actual course of certain veins and their true nature.

I have much pleasure in naming this genus after Dr. R. J. Tillyard, whose researches on the venation of the wings of nymphs of recent insects have helped to interpret the older fossil forms.

Tillyardia multiplicata, sp. nov. Plate X, fig. 2; Text-figure 45.

Type.—Greater part of the impression of the under surface of a right wing; Museum of Geological Survey of Scotland, Edinburgh (no. T. 4098b).

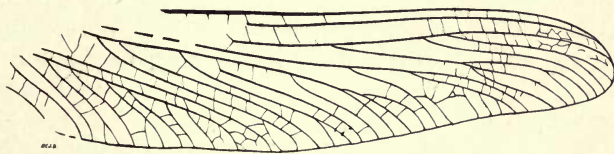


FIG. 45.—*Tillyardia multiplicata*, sp. nov.; diagram of venation of right wing, enlarged one-and-a-half times. Upper Coal Measures; Barony Pit, Auchinleck, Ayrshire. Museum of Geological Survey of Scotland, Edinburgh (no. T. 4098b).

Horizon and Locality.—Upper Coal Measures; Barony Pit, Auchinleck, Ayrshire.

Specific Characters.—As above.

Description.—The wing lies on the irregular surface of a soft purple sandstone, is imperfect, and has been badly rubbed, so that the junctions of some of the veins have been obscured. The whole of the base of the wing is missing, and the middle portion of the impression of the wing has also been destroyed. It is 67 mm. long and 13 mm. wide.

The outer margin appears to have been almost straight over the greater part of its length, inclining gently into the wing-apex, the latter joining the inner margin in a blunt right-angle. By analogy with the Protodonata, the outer margin was extended outwardly in its basal half, and the subcostal area was widened out. This feature is seen in *Paralogus æschnoides*, Scd., with which the wing has much in common. No trace of an undoubted subcostal vein is distinguishable. It must therefore have been short, and joined to the outer margin in the basal half. The radius is a long vein, parallel with the outer margin, and

reaching the wing-apex, curving inwards as it does so. The junctions of the branches of the radial sector are destroyed. It would seem to have begun between the radius and the median as an accessory vein, rather than as an offshoot of the radius. Its branches occupy the outer half of the wing-apex. The median is a large and important vein, dividing near the base into two branches. The outer branch is undivided until close to the distal end of the outer margin, where it gives off an outer and two inner twigs. The inner branch of the median gives off five simple inner twigs, and an outer one which forks close to the margin. The cubitus is represented by two veins, an outer vein which remains undivided and an inner which gives off at least five twigs. It is possible that the vein which I thus describe as the cubitus is really part of a cubito-anal, but as the basal part is missing the exact conditions cannot be determined. The inner margin of the wing is nearly straight.

Affinities.—The wing-structure, so far as it can be made out, is much like that of *Paralogus æschnoides*, Sed., and *Protagrion audouini*, Brong., and of these it more nearly accords with the latter in its great length as contrasted with the breadth. The plication of the wing is unusually well developed, and is a feature best seen in *P. æschnoides*. The presence of accessory sectors is again a feature seen in *Protagrion*. The general wing-structure, therefore, has certain characters of both genera, and where it departs from the one it approaches the other.

ADDENDUM.

Archimylacris pringlei, Bolton. Plate X, fig. 3.

1921. *Archimylacris pringlei*, Bolton, Quart. Journ. Geol. Soc., vol. lxxvii, pp. 23—29, pl. i, figs. 1—2, text-fig. 1.

Type.—The basal two-thirds of a fore-wing, and counterpart impression, partly obscured by plant remains; Museum of Practical Geology, Jermyn Street (nos. 30725, 30726).

Horizon and Locality.—Keele Group, Upper Division of the Coal Measures; from rocks between the surface level and 97 feet in borehole at Slang Lane, Wellington, Shropshire.

Specific Characters.—Wing twice to two-and-a-half times as long as wide, costal margin flattened; subcostal area strap-shaped and very wide, crossed by numerous parallel branches of the subcosta. Radius dividing beyond middle of wing. Median parallel with radius. Cubitus curving to inner margin, with widely separated inward branches. Anal area long.

Description.—The wing-fragment has a length of 18 mm. The costal margin

is flatly convex over the greater part of its length, and well rounded at the base of the wing. The subcosta is parallel to and widely spaced from the outer margin, to which it sends eight or nine branches, two of which are forked, and one, the most distal, is not fully developed. The radius is not complete, and has but a slight divergence from the subcosta. It gives off the radial sector at a point between the seventh and eighth branches of the subcosta. The radial sector goes out to the wing-apex, sending its branches forward to the outer margin. The median diverges a little more from the radius than the latter from the subcosta. Portions of three inner branches are present. The cubitus is a convex vein passing well out to the distal end of the inner margin of the wing, and giving off a series of widely separated inward branches, of which four are present on the wing-fragment preserved. Owing to the forward displacement of the anal portion of the wing, the first branch of the cubitus passes under the first anal vein. The second shows a simple fork, and the remaining two veins end undivided on the line of fracture. Portions of six anal veins are present, the first obscure and the rest parallel. The interstitial neuration consists of a compact series of close-set transverse nervures, which in the basal areas between the radius, median, and cubitus unite laterally and irregularly until they form a coarse irregular meshwork.

Affinities.—The widely spaced subcosta and the character of the interstitial neuration of the wing show a close relationship to that of two forms of *Archimy-lacris* (*A. desaillyi* and *A. lerichei*) recorded from the Coal Measures of Liévin, Northern France, but, as the accompanying tabulated comparison will show, the wing is nevertheless specifically distinct from either.

Observations.—The presence of this fossil Blattoid in the Keele Group of the Upper Division of the Coal Measures of Shropshire, and its specific relation to forms known only from the Westphalian Series of Liévin, Northern France, is a matter of considerable interest, especially as Dr. Pruvost, of Lille, had previously drawn attention to the fact that the fauna at the top of the Coal Measures in Great Britain (Keele Group, Newcastle-under-Lyme Group, Etruria Group) does not notably differ from the fauna at the top of the Westphalian in Northern France.

TABULATED COMPARISON.

<i>A. pringlei</i> , Bolton.	<i>A. desaillyi</i> , Leriche.	<i>A. lerichei</i> , Pruvost.
Costal Area :		
Strap-shaped, widely spaced from wing-margin.	Strap-shaped, widely spaced from wing-margin.	Outer third oblique to wing-margin.
Subcostal Vein :		
Numerous divisions, mostly forking.	Numerous divisions, mostly forking.	Few divisions, much branched.

<i>A. pringlei</i> , Bolton.	<i>A. desaillyi</i> , Leriche.	<i>A. lerichei</i> , Pruvost.
Radius Vein: Few branches. Radial sector arising opposite outer fourth of subcosta.	Seven branches. Radial sector arising opposite outer third of subcosta.	Twelve branches. Radial sector arising opposite middle of subcosta.
Radial Sector: Branching not known.	Eight branches.	Seven to eight branches.
Median Vein: Branches beyond origin of radial sector.	Branches opposite first fork of radial sector.	Branches much beyond origin of radial sector.
Cubitus Vein: First branch simple, second forked.	First branch simple, second and third forked.	First branch dividing into four, second simple, third and fourth branched.
Anal Veins: Undivided.	First vein only forked.	First anal forking twice.
Interstitial neururation: Transverse nervures, except in the median basal part of the wing, where it is reticulate.	Transverse nervures, except in the median basal part of the wing, where it is reticulate.	Transverse nervures, except in the median basal part of the wing, where it is reticulate.

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— <i>incisa</i>	107; VII, 3	<i>Coselia</i>	81
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(<i>Blattoidea</i>) <i>exilis</i>	136	— <i>johnsoni</i>	96
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— recta	88; VI, 1	— obtusata	85; V, 5

CHAPTER

1. The first part of the book is devoted to a general survey of the subject. It begins with a definition of the term "philosophy" and then proceeds to a discussion of the various branches of the subject. The author then discusses the history of philosophy, from the ancient Greeks to the modern era. He then discusses the various methods of philosophy, such as logic, metaphysics, and ethics. Finally, he discusses the various schools of thought, such as Platonism, Aristotelianism, and Stoicism.

2. The second part of the book is devoted to a detailed discussion of the various branches of philosophy. It begins with a discussion of logic, which is the study of the principles of reasoning. The author then discusses metaphysics, which is the study of the nature of reality. He then discusses ethics, which is the study of the principles of morality. Finally, he discusses aesthetics, which is the study of the nature of art.

3. The third part of the book is devoted to a discussion of the various schools of thought. It begins with a discussion of Platonism, which is the philosophy of Plato. The author then discusses Aristotelianism, which is the philosophy of Aristotle. He then discusses Stoicism, which is the philosophy of the Stoics. Finally, he discusses the various other schools of thought, such as Epicureanism and Skepticism.

4. The fourth part of the book is devoted to a discussion of the various methods of philosophy. It begins with a discussion of logic, which is the study of the principles of reasoning. The author then discusses metaphysics, which is the study of the nature of reality. He then discusses ethics, which is the study of the principles of morality. Finally, he discusses aesthetics, which is the study of the nature of art.

5. The fifth part of the book is devoted to a discussion of the various branches of philosophy. It begins with a discussion of logic, which is the study of the principles of reasoning. The author then discusses metaphysics, which is the study of the nature of reality. He then discusses ethics, which is the study of the principles of morality. Finally, he discusses aesthetics, which is the study of the nature of art.

PLATE I.

FIG.

PAGE.

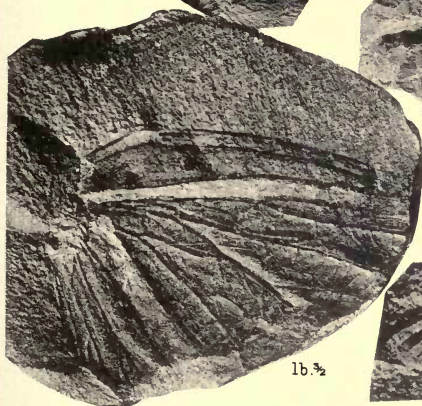
- 1a. *Dictyoneura higginsii* (Handlirsch); basal portion of left wing. $\times 1\frac{1}{2}$.
Middle Coal Measures (horizon not known); Ravenhead Railway
Cutting, nr. St. Helens, Lancashire. Liverpool Museum. 25.
- 1b. Ditto; impression of the wing. $\times 1\frac{1}{2}$. 25.
- 2a. *Orthocosta splendens*, Bolton; left wing. Natural size. Middle Coal
Measures (below the Top Hard Coal); Shipley Manor Claypit,
Ilkeston, Derbyshire. Mus. Pract. Geol. (Moysey Coll.), no. 30222. 27.
- 2b. Ditto; impression of the wing. Natural size. Mus. Pract. Geol. (Moysey
Coll.), no. 30223. 27.
- 3a. *Pteronidia plicatula*, Bolton; inner half of left wing. $\times 1\frac{1}{2}$. The
straight inner margin and the plication are well shown. Middle
Coal Measures (below the Top Hard Coal); Shipley Manor Claypit,
Ilkeston, Derbyshire. Mus. Pract. Geol. (Moysey Coll.), no. 30224. 30.
- 3b. Ditto; impression of portion of the wing, showing the oblique cross-
nervures. $\times 1\frac{1}{2}$. Mus. Pract. Geol. (Moysey Coll.), no. 30225. 30.
- 4a. *Hypermegethes northumbriæ*, Bolton; basal half of a left wing. $\times 1\frac{1}{2}$.
Coal Measures (shale above the Crow Coal); Phoenix Brickworks,
Crawcrook, Durham. British Museum, no. In. 18524. 32.
- 4b. Ditto; counterpart of portion of basal half of the wing, the interstitial
neuration having been rendered visible by immersion of the nodule
in water during photography. $\times 1\frac{1}{2}$. 32.



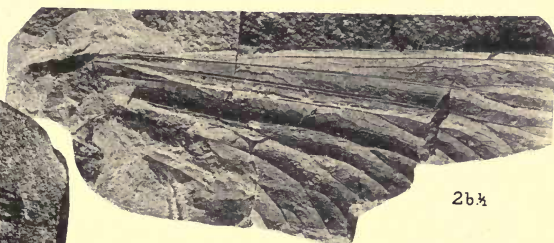
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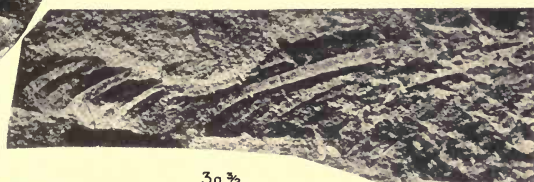
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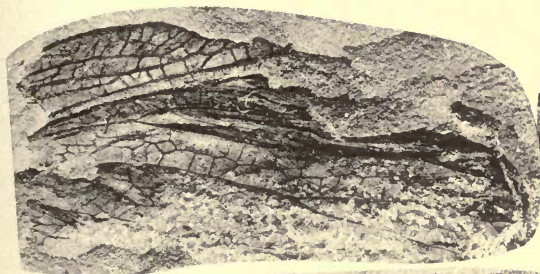
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2b. $\frac{3}{2}$



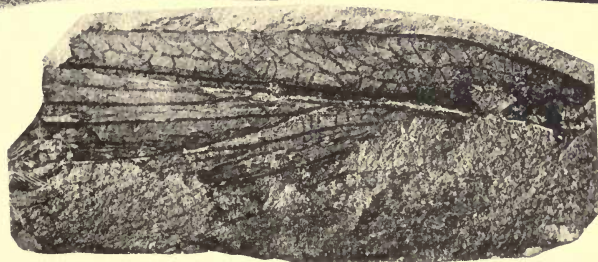
3a. $\frac{3}{2}$



4b. $\frac{3}{2}$



3b. $\frac{3}{2}$



4a. $\frac{3}{2}$

1. DICTYONEURA. 2. ORTHOCOSTA. 3. PTERONIDIA.

4. HYPERMEGETHES.

PLATE II.

FIG.

PAGE.

- 1a. *Cryptovenia moyseyi*, Bolton; greater part of left wing, dorsal surface uppermost. $\times 3\frac{1}{2}$. Middle Coal Measures (below Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire. Mus. Pract. Geol. (Moysey Coll.), no. 30226.

35.
- 1b. Ditto; impression of dorsal surface of left wing showing interstitial neuration. $\times 3\frac{1}{2}$.

35.
- 2a. *Mecynoptera tuberculata*, sp. nov.; portions of two fore-wings and cubito-anal portion of hind-wing superposed. $\times 1\frac{1}{2}$. Middle Coal Measures (shales above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire. British Museum, no. In. 18576.

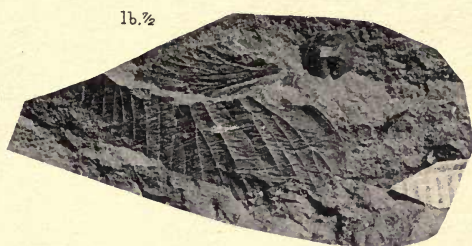
37.
- 2b. Ditto; impression of the two fore-wings showing interstitial neuration. $\times 1\frac{1}{2}$.

37.
- 3a. *Palæomantis macroptera*, Bolton; fragment of left wing, dorsal aspect, the underside of the right wing showing beneath. Natural size. Middle Coal Measures; Ravenhead railway cutting near St. Helens, Lancashire. Liverpool Museum.

40.
- 3b. Ditto; impression of greater part of dorsal surface of left wing. Natural size.

40.
4. *Lithomantis carbonarius*, Woodward; portions of fore- and hind-wing, the prothorax with domed lateral lobes, and the anterior styliform process. (The latter ends in a sharp point not shown in the photograph. A little of the mesothorax is seen between the bases of the fore-wings.) Natural size. Coal Measures; Scotland. British Museum, no. I. 8118.

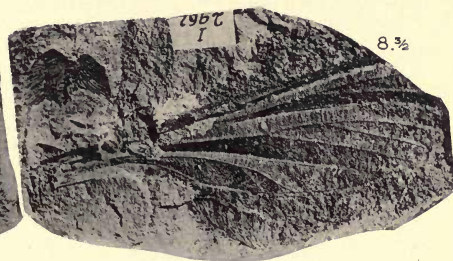
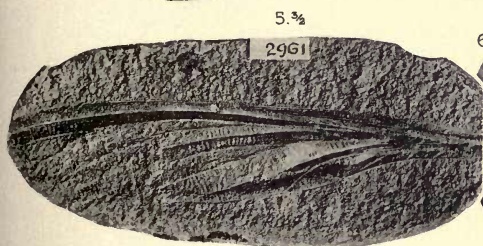
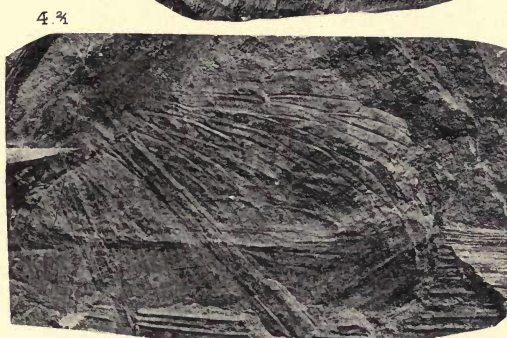
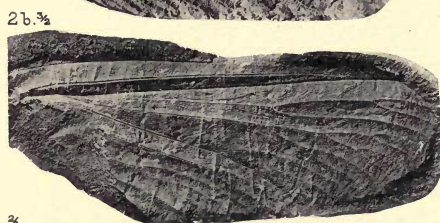
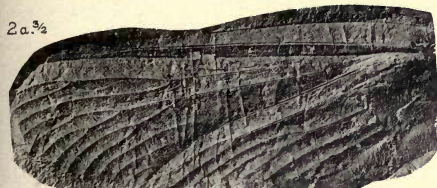
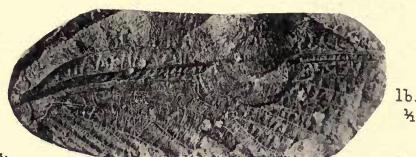
43.

1a. $\frac{1}{2}$ 1b. $\frac{1}{2}$ 2a.
 $\frac{3}{2}$ 2b. $\frac{3}{2}$ 3a. $\frac{1}{2}$ 3b. $\frac{1}{2}$ 4. $\frac{1}{2}$

1. CRYPTOVENIA. 2. MECYNOPTERA. 3. PALÆOMANTIS.
4. LITHOMANTIS.

PLATE III.

FIG.	PAGE.
1a. <i>Lithosialis brongniarti</i> (Mantell); left fore-wing. Natural size. Coal Measures; near Coalbrookdale, Shropshire. British Museum (Mantell Coll. <i>olim</i> Parkinson Coll.), no. 11619.	46.
1b. Ditto; impression of greater part of left fore-wing. Natural size.	46.
2a. <i>Pruvostia spectabilis</i> , gen. et sp. nov.; left fore-wing. $\times 1\frac{1}{2}$. Middle Coal Measures (ironstone nodules in the binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffordshire. British Museum (Johnson Coll.), no. I. 15894.	48.
2b. Ditto; impression of same. $\times 1\frac{1}{2}$.	48.
3. <i>Spilaptera sutcliffei</i> , Bolton; basal part of left wing. $\times 1\frac{1}{2}$. Middle Coal Measures (shales above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire. Manchester Museum, no. L. 8197.	54.
4. <i>Boltoniella tenuitegminata</i> (Bolton); right hind-wing. $\times 2$. Coal Measures (No. 2 Rhondda Seam, base of Pennant Series); $1\frac{3}{4}$ miles north-east of Resolven Station, Glamorganshire. Mus. Pract. Geol., no. 24509.	56.
5. <i>Brodia priscotincta</i> , Scudder; almost complete left wing, showing the attenuated base. $\times 1\frac{1}{2}$. Middle Coal Measures (clay ironstone nodule from binds between the "Brooch" and "Thick" Coals); Dudley, Staffordshire. British Museum, no. I. 2961.	59.
6. Ditto; portion of right hind-wing, under surface uppermost. (The original furrows of the wing have been flattened out, the veins more widely separated.) $\times 1\frac{3}{4}$. Middle Coal Measures (clay ironstone nodule from binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum, no. In. 18431.	59
7. <i>Brodia furcata</i> , Handlirsch; wing lacking about one-sixth of the apical end. $\times 2$. Middle Coal Measures (above the "Brooch" Coal); Dudley, Staffordshire. British Museum, no. I. 2962.	66.
8. Ditto; impression of same, showing the narrow base of wing. $\times 1\frac{1}{2}$.	66.

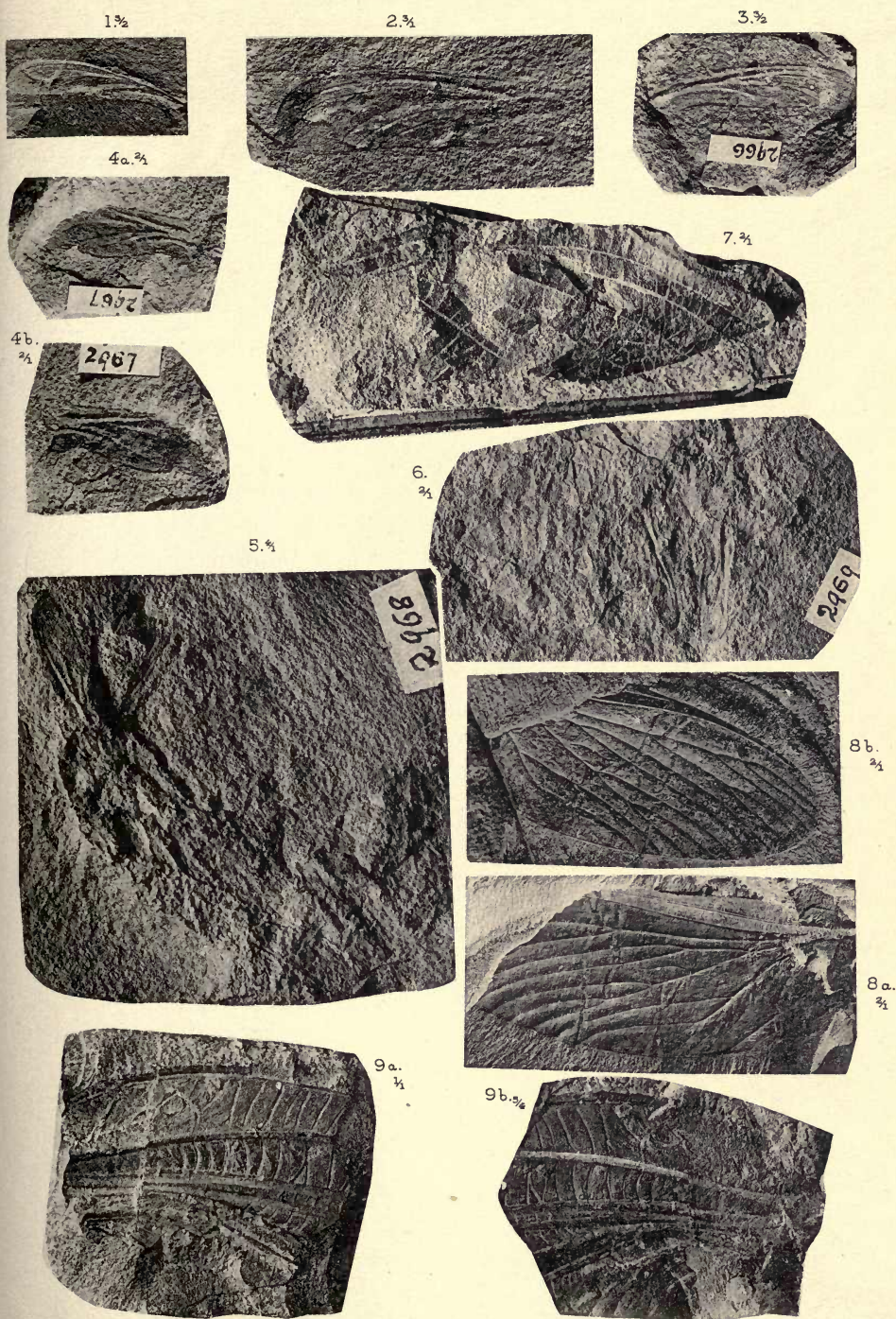


1. LITHOSIALIS. 2. PRUVOSTIA. 3. SPILAPTERA.

4. BOLTONIELLA. 5-8. BRODIA.

PLATE IV.

Fig.		PAGE.
1.	<i>Brodia priscotincta</i> , Scudder (<i>juvenis</i>); wing. $\times 1\frac{1}{2}$. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum, no. I. 1563.	63.
2.	Ditto; slightly older wing with a broad base. $\times 3$. Middle Coal Measures (binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum, no. I. 1564.	63.
3.	<i>Brodia priscotincta</i> , Scudder; immature wing. $\times 1\frac{1}{2}$. Middle Coal Measures (binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Madeley Coll.), no. I. 2966.	59.
4a.	" <i>Pteronepionites</i> " <i>johnsoni</i> , sp. nov.; very immature wing. $\times 2$. Middle Coal Measures (binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Madeley Coll.), no. I. 2967.	68.
4b.	Ditto; impression of same showing undeveloped apex of wing. $\times 2$.	68.
5.	" <i>Pteronepionites</i> " <i>ambigua</i> , sp. nov.; crushed larval insect with partially developed wings. $\times 4$. Middle Coal Measures (binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Madeley Coll.), no. I. 2968.	68.
6.	" <i>Pteronepionites</i> " <i>lepus</i> , sp. nov.; remains of larval insect with immature wings and long segmented abdomen, the photograph accidentally placed upside down. $\times 2$. (Obscure traces of what may have been pleural spines can be distinguished.) Middle Coal Measures (binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Madeley Coll.), no. I. 2969.	69.
7.	<i>Ænigmatodes</i> (?) <i>regularis</i> , sp. nov.; portion of inner half of wing. $\times 2$. Middle Coal Measures (over the Barnsley Thick Coal); Monckton Main Colliery, Barnsley, Yorkshire. British Museum, no. In. 18604.	71.
8a.	<i>Pseudofouquea cambrensis</i> (Allen); greater part of left wing. $\times 2$. Lower Coal Measures (top of the Four Foot Seam); Llanbradach Colliery. Mus. Pract. Geol., no. 7272.	72.
8b.	Ditto; impression of missing apex of same wing. $\times 2$.	72.
9a.	<i>Archæoptilus ingens</i> , Scudder; basal fifth of (? right) wing. Natural size. Middle Upper Coal Measures; between Shelton and Clay Lane, near Chesterfield, Derbyshire. British Museum, no. I. 3997.	74.
9b.	Ditto; impression of same. $\times 1\frac{1}{4}$. British Museum, no. I. 3997.	74.



1-3. BRODIA. 4-6. PTERONEPIONITES. 7. ÆNIGMATODES.

8. PSEUDOFUQUEA. 9. ARCHÆOPTILUS.

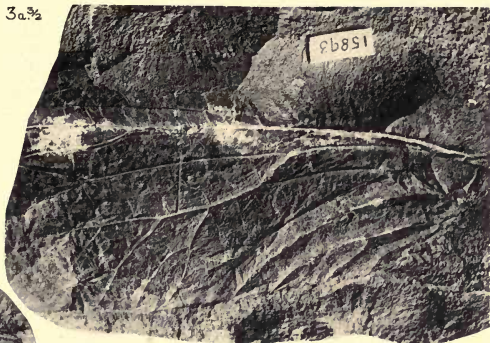
PLATE V.

FIG.	PAGE.
1. <i>Geroneura</i> (?) <i>ovata</i> , sp. nov.; impression of upper surface of apex of left wing. $\times 1\frac{1}{2}$. Middle Coal Measures (binds between "Brooch" and "Thick" Coals); British Museum (Madeley Coll.), no. I. 2965.	77.
2 a. <i>Ædæophasma anglica</i> , Scudder; almost complete left wing. $\times 1$. Middle Coal Measures; Ravenhead Railway Cutting, near St. Helens, Lancashire. Liverpool Museum.	78.
2 b. Ditto; impression of same. $\times 1$.	78.
3 a. <i>Coselia palmiformis</i> , gen. et sp. nov.; basal half of left wing. $\times 1\frac{1}{2}$. Middle Coal Measures (binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Johnson Coll.), no. I. 15893.	81.
3 b. Ditto; impression of same showing the intercostal area. $\times 1\frac{1}{2}$.	81.
4 a. <i>Genentomum</i> (?) <i>subacutum</i> , Bolton; apical parts of two wings. $\times 3\frac{1}{2}$. Lower Coal Measures (637 feet below the Bedminster Great Vein); South Liberty Colliery, Bristol, Somerset. Bristol Museum, no. C. 972.	84.
4 b. Ditto; impression of same. $\times 3\frac{1}{2}$.	84.
5 a. <i>Xeroptera obtusata</i> , gen. et sp. nov.; greater part of right fore-wing lacking the outer margin. $\times 2$. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Johnson Coll.), no I. 1558.	85.
5 b. Ditto; impression of same. $\times 2$.	85.

1½



3a.¾

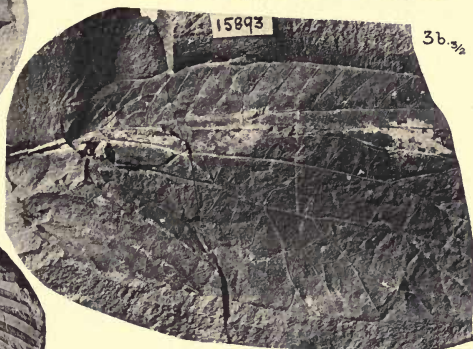


2a.¼



15893

3b.¾



2b.¼



4b.¾



5a.¾



4a.¾

5b.¾



1. GERONEURA? 2. ÆDCEOPHASMA. 3. COSELIA.

4. GENENTOMUM. 5. XEROPTERA.

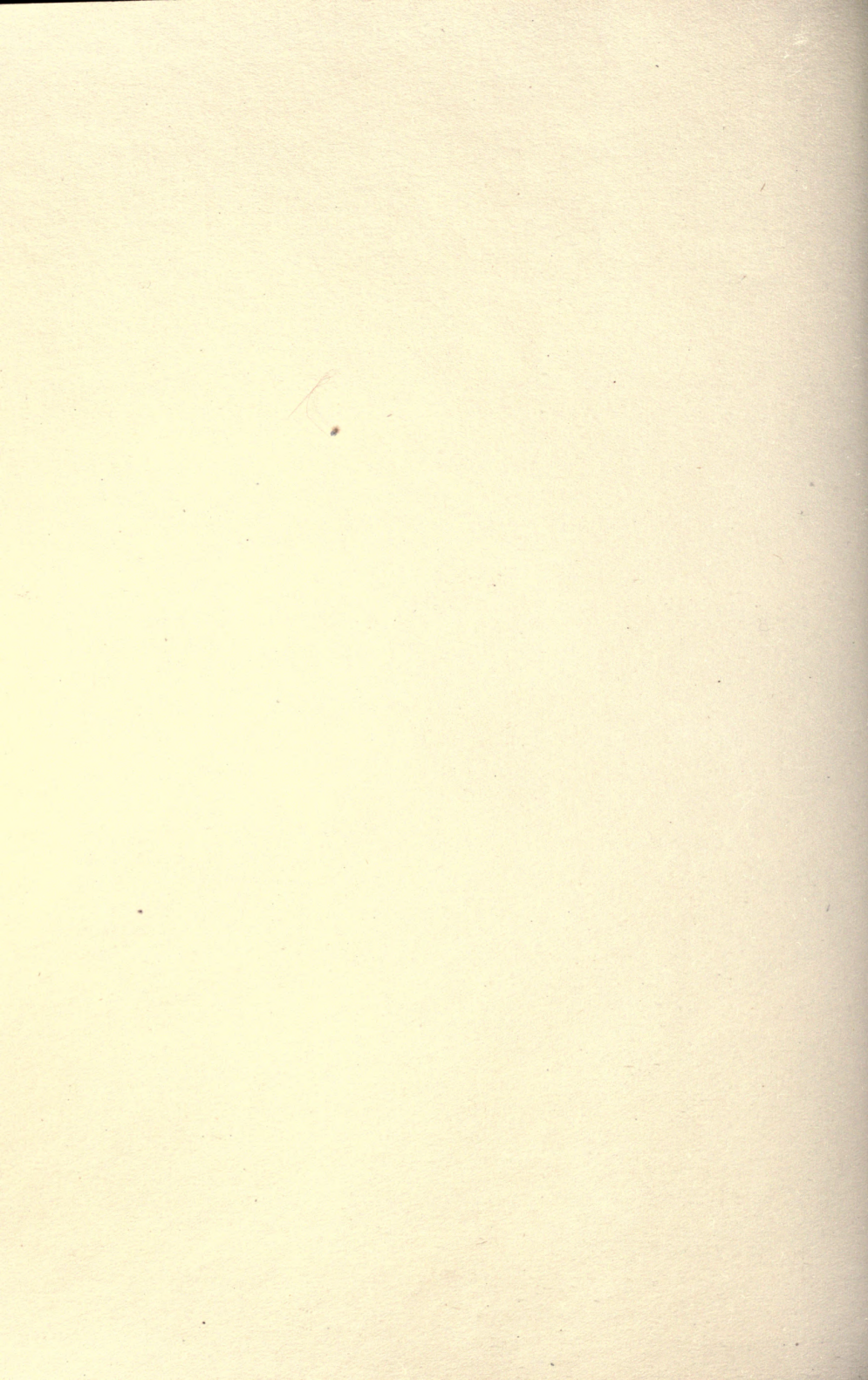


PLATE VI.

FIG.		PAGE.
1 a.	<i>Scalæoptera recta</i> , sp. nov.; basal half of left wing. $\times 2$. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, nr. Dudley, Staffordshire. British Museum, no. I. 13878.	88.
1 b.	Ditto; impression of the same wing-fragment. $\times 2$.	88.
2.	<i>Ptenodera dubius</i> , sp. nov.; distal half of left wing. $\times 3$. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, nr. Dudley, Staffordshire. British Museum (Johnson Coll.), no. I. 1559.	91.
3 a.	<i>Plesiodischia</i> , sp.; fragment of right wing. $\times 1\frac{1}{2}$. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Tipton, Staffordshire. Manchester Museum, no. L. 4905.	92.
3 b.	Portion of costal border of same wing borne on opposite half of nodule. $\times 1\frac{1}{2}$.	92.
4.	<i>Aphthoroblattina johnsoni</i> (Woodward); type specimen. $\times 1\frac{1}{2}$. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Johnson Coll.), no. I. 1067.	96.
5 a.	Ditto. $\times 2$. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, Staffordshire. Mr. W. Egginton's Collection, no. 2.	99.
5 b.	Ditto; impression. $\times 2$.	99.
6 a.	<i>Aphthoroblattina eggintoni</i> , sp. nov.; pronotum, portions of tegmina, and the distal portion of left hind-wing showing beyond broken edge of tegmen. $\times 2$. Middle Coal Measures (binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. Mr. W. Egginton's Collection, no. 1.	100.
6 b.	Ditto; counterpart. $\times 2$.	100.

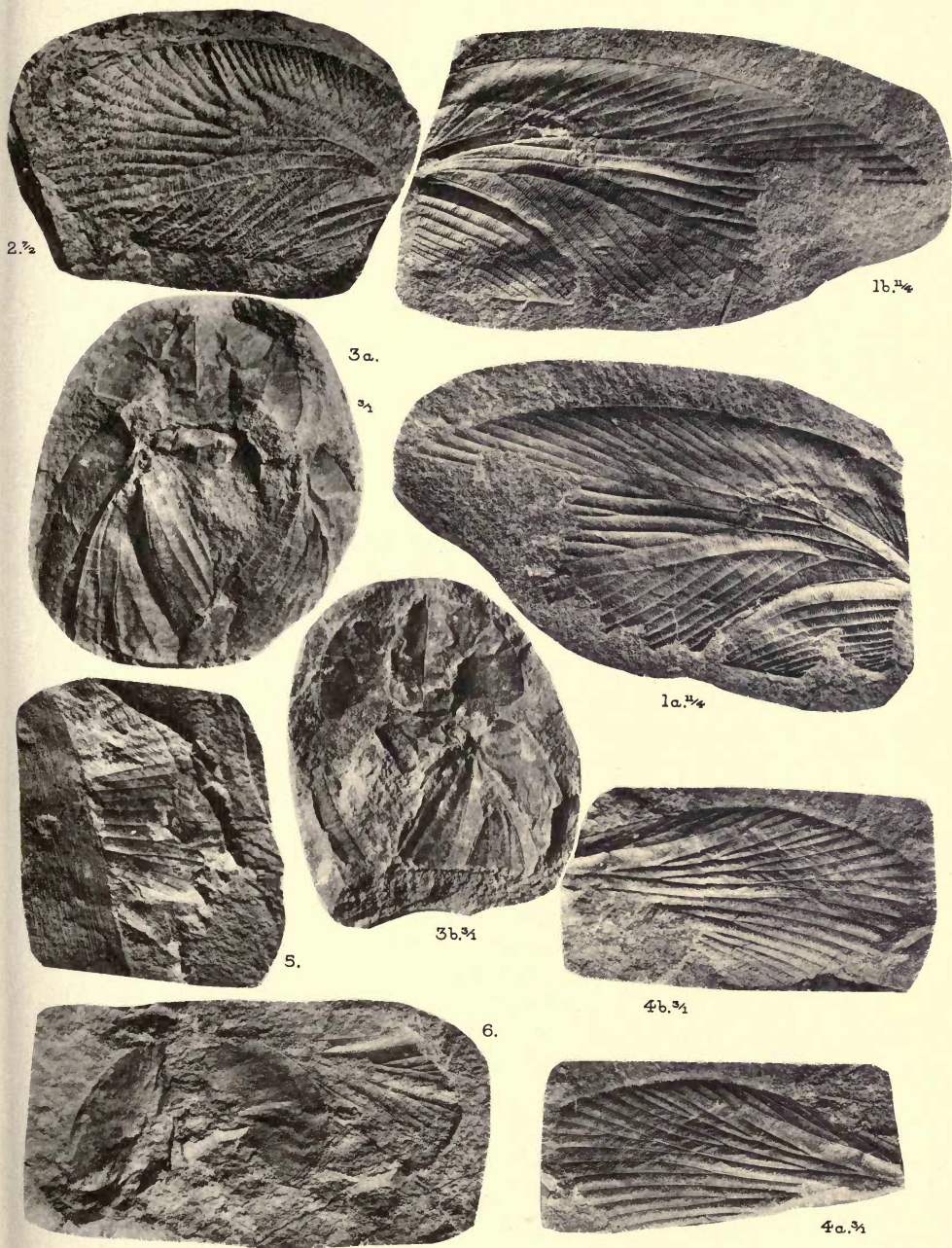


1. SCALÆOPTERA. 2. PTENODERA. 3. PLESIODISCHIA.

4-6. APHTHOROBLATTINA.

PLATE VII.

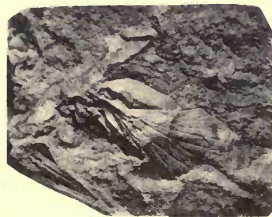
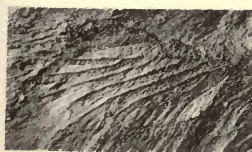
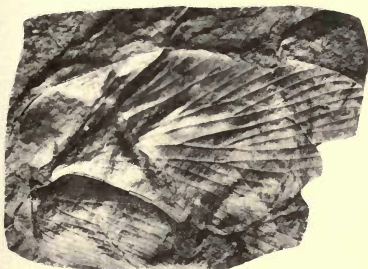
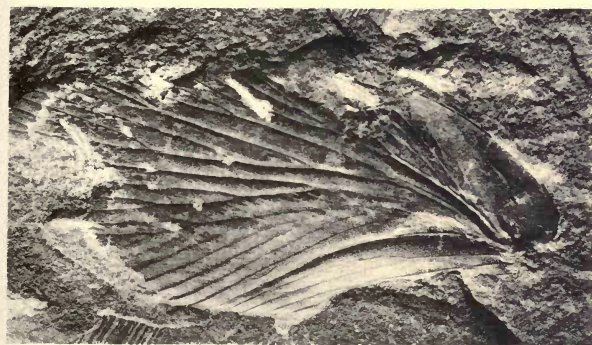
FIG.	PAGE.
1 a. <i>Archimylacris hastata</i> , Bolton; greater part of left fore-wing. $\times 2\frac{3}{4}$. Base of Upper Coal Measures (Gellideg Level of Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol., no. 24501.	103.
1 b. Ditto; counterpart of left wing. $\times 2\frac{3}{4}$. Mus. Pract. Geol., no. 24502.	103.
2 <i>Archimylacris woodwardi</i> , Bolton; left fore-wing. $\times 3\frac{1}{2}$. Base of Pennant Series (10 feet shale overlying the No. 2 Rhondda seam); Clydach Vale, South Wales. Mr. D. Davies' Coll.	106.
3 a. <i>Archimylacris incisa</i> , sp. nov.; impression of the under surface of the pronotum, and of the remnants of the fore-wings. $\times 3$. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, nr. Dudley, Staffordshire. British Museum (Johnson Coll.), no. I. 15900.	107.
3 b. Ditto; counterpart. $\times 3$.	107.
4 a. <i>Archimylacris obovata</i> , Bolton; portion of left fore-wing. $\times 3$. Upper Coal Measures (Gwernau Level of the Mynyddislwyn Vein); Maes-y- cwmmer, Monmouthshire. Mus. Pract. Geol., no. 24506.	109.
4 b. Ditto; impression—less incomplete than the broken wing. $\times 3$. Mus. Pract. Geol., no. 24507.	109.
5. <i>Archimylacris</i> , sp. indet.; fragmentary fore-wing, showing the middle third only, the rest being concealed under a leaf of <i>Cordaites</i> , the latter bearing pits in which <i>Spirorbis pusillus</i> (Martin) had established themselves. Much enlarged. Base of Upper Coal Measures (Gellideg Level of Mynyddislwyn Vein); near Maes-y- cwmmer, Monmouthshire. Mus. Pract. Geol., no. 24503.	112.
6. <i>Archimylacris</i> , sp. indet.; impression of the basal portion of a left fore-wing, and of a broken pronotum. Much enlarged. Base of Upper Coal Measures (Gellideg Level of Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol., no. 24508.	113.



1-6. ARCHIMYLACRIS.

PLATE VIII.

FIG.	PAGE.
1 <i>a.</i> <i>Phylloblatta sulcata</i> (Bolton); greater part of a right fore-wing. $\times 3$. Upper Coal Measures (Gwernau Level of the Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol., no. 24504.	113.
1 <i>b.</i> Ditto; counterpart. $\times 3$.	113.
2. <i>Phylloblatta transversalis</i> , Bolton; remains of two Blattoids, consisting of the tegmina, pronota, and portions of the hind-wings. Natural size. Coal Measures; Staffordshire. Geological Museum, University, Birmingham.	115.
3. (Archimylacridæ) <i>kirkbyi</i> (Woodward); reproduction of Woodward's figure of a single left wing. $\times 5$. Upper Coal Measures (bed no. 33); Meithil, coast of Fifeshire. Present whereabouts of specimen unknown; formerly in the possession of Mr. James Kirkby.	118.
4 <i>a.</i> <i>Phylloblatta</i> (?) sp.; portion of Blattoid wing. $\times 4\frac{1}{2}$. Coal Measures (shales at a depth of 1967 feet); Maydensole boring, Kent. Museum of the Kent Coals Concession Co., Dover.	119.
4 <i>b.</i> Ditto; impression. $\times 4\frac{1}{2}$.	119.
5 <i>a.</i> <i>Phylloblatta</i> (?) sp.; portion of Blattoid wing. $\times 4\frac{1}{2}$. Coal Measures (at depth of 2180 feet); Barfreston boring, Kent. Museum of the Kent Coal Concessions Co., Dover.	119.
5 <i>b.</i> Ditto; outline of wing-fragment. $\times 4\frac{1}{2}$.	119.
6. Blattoid wing-fragment. $\times 4$. Found in a core from a depth of 2424 feet at the Stonehall boring, Kent. Museum of the Kent Coal Concessions Co., Dover.	120.
7. <i>Hemimylacris obtusa</i> , Bolton; right fore-wing. $\times 2\frac{1}{2}$. Base of Upper Coal Measures (Four-foot Seam of Swansea); Gladys Colliery, one mile E.S.E. of Penller-gaer Church, Glamorganshire. Mus. Pract. Geol., no. 24510.	122.
8. <i>Hemimylacris convexa</i> , Bolton; basal half of a fore-wing. $\times 3\frac{1}{2}$. Coal Measures (shales associated with the Graigola Seam, Pennant Series); Clydach Merthyr Colliery, Clydach Valley, Swansea Vale, Glamorganshire.	123.



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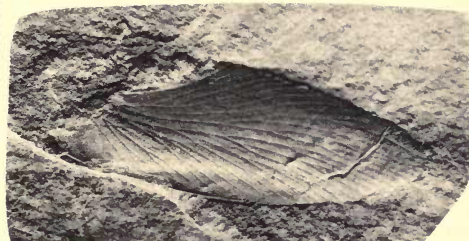
8. $\frac{1}{2}$

1. 2. 4. 5. PHYLOBLATTA. 3. ARCHIMYLACRIDAE.

6. BLATTOID WING FRAGMENT. 7. 8. HEMIMYLACRIS.

PLATE IX.

Fig.		PAGE.
1.	<i>Phylomylacris mantidioides</i> (Goldenberg); basal portion of a left fore-wing. $\times 4\frac{1}{2}$. Upper Coal Measures (zone of <i>Anthracomya phillipsii</i>); South Hylton, opposite Claxbeugh on the Wear, Durham. Hancock Museum, Newcastle-on-Tyne (Kirkby Coll.).	125.
2.	<i>Soomylacris deanensis</i> (Scudder); a right fore-wing, showing the under surface. $\times 1\frac{1}{2}$. Found by Mr. F. Stock in Coal Measures at Foxe's Bridge, Forest of Dean, Gloucestershire. U.S. National Museum, Washington, D.C. (Lacoe Coll., no. H. 2132 <i>b</i> ; Nat. Mus., no. 38090).	128.
3.	<i>Soomylacris stocki</i> , sp. nov.; fragmentary remains of a fore-wing, partly overlaid by the remains of a second. $\times 2\frac{1}{2}$. Found by Mr. F. Stock in Coal Measures at Crump Meadow, Forest of Dean, Gloucestershire. U.S. National Museum, Washington, D.C. (Lacoe Coll., no. H. 2132 <i>c</i> ; Nat. Mus., no. 38090).	130.
4.	<i>Soomylacris burri</i> , Bolton; almost complete fore-wing. $\times 4\frac{1}{2}$. Coal Measures (in dark shale from a depth of 1208 feet); Barfreston Boring, Kent. Museum of the Kent Coal Concessions Co., Dover.	131.
5.	<i>Orthomylacris lanceolata</i> , Bolton; left fore-wing, with the base missing. $\times 2\frac{1}{2}$. Coal measures (shales associated with the Graigola Seam, Pennant Series); Clydach Merthyr Colliery, Clydach Valley, Swansea Vale, Glamorganshire. Mus. Pract. Geol., no. 24511.	133.
6.	(<i>Blattoidea</i>) <i>peachi</i> (Woodward); complete upper surface of insect, showing the head, pronotum, larval wings, and the segments of the abdomen. $\times 2\frac{1}{2}$. Coal Measures (grey sandy shale with nodules of impure clay and ironstone, at 91 feet 6 inches below the surface); Greenhill Pit, Kilmarnock. Kilmarnock Museum.	134.
7.	<i>Leptoblattina exilis</i> , Woodward; co-type of almost complete insect, seen from the upper surface. $\times 2$. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Johnson Coll.), no. 1065.	136.
8.	Ditto; a second co-type, with the enlarged epimera well seen on the left side of the abdomen. $\times 2$. British Museum (Johnson Coll.), no. 1066.	136.

2. $\frac{3}{2}$ 1. $\frac{3}{2}$ 3. $\frac{5}{2}$ 4. $\frac{3}{2}$ 5. $\frac{3}{4}$ 6. $\frac{3}{2}$ 7. $\frac{3}{4}$ 8. $\frac{3}{4}$

1. PHYLOMYLACRIS. 2-4. SOOMYLACRIS. 5. ORTHOMYLACRIS.

6. (BLATTOIDEA.) 7. 8. LEPTOBLATTINA.

PLATE X.

FIG.		PAGE.
1a.	<i>Boltonites radstockensis</i> (Bolton); basal portion of the wing. $\times 2$. Upper Coal Measures; Tynning Colliery, Radstock, Somersetshire. Sedgwick Museum, Cambridge.	140.
1b.	Ditto; proximal portion of costa and subcosta, showing the tubercular anterior edge, and the backward slipping of the costa over the sub- costa. $\times 4$.	140.
1c.	Ditto; distal portion of the costa and subcosta, showing the spinous anterior border of the former, the cross-branches uniting the two veins, and a median line of tubercular ornament on the subcosta. $\times 4$.	140.
1d.	Ditto; proximal portion of the inner margin, showing the development of stout submarginal spines. $\times 4$.	140.
1e.	Ditto; more distal portion of the inner margin, showing the submarginal spines. $\times 4$.	140.
2.	<i>Tillyardia multiplicata</i> , gen. et sp. nov.; impression of the under surface of right wing. $\times 1\frac{1}{2}$. Upper Coal Measures; Barony Pit, Auchinleck, Ayrshire. Mus. Geol. Surv. Scot., no. T. 4098 b.	145.
3.	<i>Archimyrlacris pringlei</i> , Bolton; basal two-thirds of fore-wing. $\times 4$. Upper Coal Measures (Keele Group); Slang Lane, Wellington, Shropshire. Mus. Pract. Geol., no. 30725.	146.



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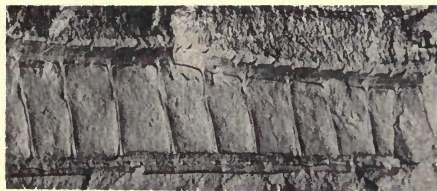
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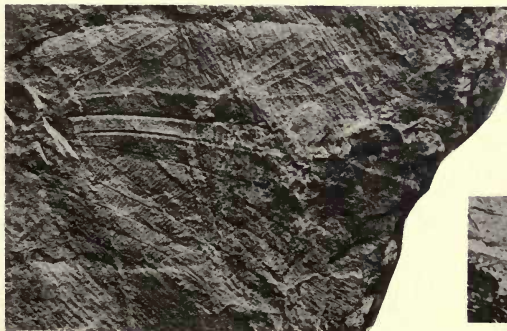
1b.

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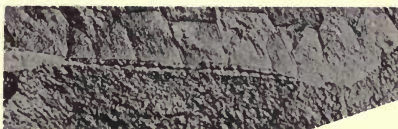
1c.

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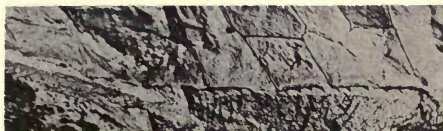
3.

$\frac{3}{4}$



1e.

$\frac{3}{4}$



1d.

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1a-e. BOLTONITES. 2. TILLYARDIA.

3. ARCHIMYLACRIS.

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